ANALYSIS OF VULNERABILITY OF FRUIT, VEGETABLES AND TABLE GRAPES SECTOR TO CLIMATE CHANGE (DROUGHT) IN THE HERZEGOVINA REGION

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ABBREVIATIONS

ABA-hormone of abscisic acid

Dv - deficit or shortage of water

ETc - potential evapotranspiration

Eto - reference evapotranspiration

FAZ - photosynthetically active radiation

HS - thermal shock proteins (heat - shock proteins)

INC - Initial National Communication on Climate Change (I National report on climate changes)

IPV - Integrated Fruit Production

IPCC - Intergovernmental Panel of the United Nations climate change (Intergovernmental Panel on Climate Change)

Kc - plant ratio

LKV - lento-capillary moisture

Nn - standards of irrigation of agricultural crops

Oef - effective precipitation

PVK - field water capacity of the soil

SNC - Second National Communication on Climate Change (II National report on climate changes)

SNI-standardized precipitation index (Standardized Precipitation Index)

UNFCCC - United Nations Framework Convention on Climate Change (United Nations Framework Convention on Climate Change)

Vgod - the annual water balance

VV - wilting humidity

Vveg - vegetation water balance

WWF - World Wide Fund for Nature (World Wildlife)

CONTENT

1. INTRODUCTION

In recent years, there has been a variety of discussions on climate change, especially on the increase of average temperature of ground layer of the atmosphere. Although the theory about the cause of warming, i.e. greenhouse gases, is very likely, the final effects of increased atmospheric temperature in other climatic elements such as rainfall and the occurrence of drought in a particular area are not well known.It is anticipated that the impact of future climate change on the agricultural sector will be significant and mostly negative.

Selected occurrences of ecological crisis, primarily phenomena of drought, have made it to the agenda of the international law. Country by country, region by region, are included in uniquely designed, organized and managed removal of environmental threats, especially warming, lack of rainfall and drought as the agro-environmental factors.

Drought is largely an environmental and economic problem. In poor countries, drought is often compared to situations of life and death. Although droughts cannot be prevented, there are ways that the negative effects of drought on food production, economics and other social phenomena are reduced.

Any increase in temperature is likely to have very adverse effects, especially because of the projected higher temperatures associated with low rainfall and high evaporation rates, commonly found in the Mediterranean and sub-Mediterranean climate. Increased average temperature rise will result in costly process of adaptation to climate change, and the impact that will exceed the capacity of adaptability to a large number of ecological systems, and high-risk large-scale irreversible effects involving the disappearance of some species.

Drought and shortage of options for irrigation are not uniform, however, the area of the region of Herzegovina is one of the areas that are most affected by the shortage of water in the soil.Agriculture, especially the fruit and vegetable sector, due to their exposure and vulnerability to natural changes, is the sector most vulnerable to climate change, particularly the occurrence of drought. Theories about some of the benefits of the negative impacts of climate change and drought on the benefits and some additional features, primarilytwo, or even three harvests a year, an increase of breeding of late crops, higher yields and others are illusions.Thus, the projected rise in temperature in combination with changes in precipitation and evaporation rates, are likely to significantly adversely affect agricultural systems in the sub-Mediterranean area, especially the study area of Herzegovina region.

Certainly, methodological and scientific approach to the study defines adaptation to climate change with a focus on improved management of water resources and adequate irrigation system, as well as various improvements in agricultural production in drier conditions.

Efforts for rational and sustainable use of the proposed measures in the system analyzes the vulnerability of fruits, vegetables and table grapes to climate change (drought) in the Herzegovina region is all the more significant if we take into account that the real chance that this segment of agriculture can be sustainable, labor-intensive, export-oriented and profitable.

The study points to the measures and procedures that successfully overcame the problems of negative consequences of global warming and the frequent appearance of a lack of rainfall (drought) and suggests solutions and models of rational and sustainable production. The detailed elaboration of production, economic, environmental and other aspects relevant to this study for the development of the fruit,vegetables and table grapes arguments is acceptable and can be a "motor" of agricultural development in the region of Herzegovina.

We hope that this study will create a climate and preconditions that will lead to the development of projects in the area, to motivate people of Herzegovina region toward sustainable and profitable production.

1.1. Background of the problem

The current global agro-ecological deviations, above all the lack of precipitation (drought), including socio-economic aspects, have a very complex impact on the overall agricultural sector, certainly in fruit, vegetables and table grapes as a strategic segment of agriculture in the Herzegovina region. During the current strategic commitment to agriculture, through which the Herzegovina regionhas passed, the main attention was focused on some secondary issues. This region has not been understood as a production area that with the investments could become a respectable manufacturer and exporter of fruits, vegetables and table grapes.In this context, the production, with all the agro-ecological problems (frequent droughts) was left to "itself" and poorly thought-out structural adjustment. Therefore, there exists an absence of more comprehensive and systematic efforts to create effective ways to activate significant agricultural potential of the region of Herzegovina.

The lack of a thorough review of the development of agriculture sector in earlier periods (with the exception of agricultural development strategies of HNC as encouraging document), especially the analysis of the vulnerability of priority segments of agriculture in this region (fruits, vegetables and table grapes), has been an obstacle. This document may be the chance for sustainable development of total agricultural activities and to reduce the imbalance created between the real (very large) capabilities and achievements of primary production of fruits, vegetables, table grapes and other products in the scope of crop production.

The**target groups** to be highlighted for the realization of this study could be:

- Municipalities: Mostar, Capljina, Citluk, Jablanica, Konjic, Neum, Prozor-Rama, Ravno, Stolac, Grude, Ljubuski, Posusje, Siroki Brijeg, Kupres, Livno, Tomislavgrad, Berkovici, Bileca, Gacko, Istocni Mostar, Nevesinje, Trebinje, Ljubinje;
- The population of rural areas of these municipalities;
- All of the active participants in the production value chain and consumption of food, including stakeholders of the planning of the entire economy, especially the rural development of the Herzegovina region.

The study will involve the widest range of interested social actors, and also the results of studies will be using by the widest range of interested farmers to produce fruits, vegetables and table grapes.

Potential users of the Study are**:**

- Government HNC (Ministry of Forestry, Agriculture and Water Resources);
- Future creators of development strategies and related strategic documents HNC;
- Agricultural producers and processors, representatives of manufacturing activities (associations, cooperatives, farmers and others in various production sectors);
- Faculty and the University, particularly Institutes dealing with agrarian economy or production technologies;
- Government and non-governmental organizations dealing with the protection and valorization of ambient resources;
- Representatives of the socio-cultural associations;
- USAID as financiers of the study, as well as other international donor organizations that participate in the reform of the agricultural sector;
- Other subjects, holders of the collective interest.

1.2. Objective and methodology of analysis

The aim of the Study "Vulnerability Analysis of fruits, vegetables and table grapes sector on climate change (drought) in a region of Herzegovina", should to a large extent contribute to the increase of primary agricultural products and their derivatives, export potential and higher realized foreign exchange positions in the Herzegovina region, and certainly higher profits to farmers.

In a broader sense, this study should contribute to the valorization of the area of Herzegovina region, the development of micro and macro enterprises to benefit primarily producers of fruits, vegetables, table grapes, and other manufacturing. The implementation of the study will certainly expand the network to strengthen all subjects in the Herzegovina region who are engaged in the sector of primary production and processing, rural development, environmental protection, promotion of agro-tourism in the overall territorial valorization.

The implementation of the proposals from this document - Study- is based on four components:

- The agricultural population and all its features.
- The overall economy of the region Herzegovina, where a segment of agriculture, especially the rural areas in the production of fruits, vegetables and table grapes could occupy a primary place.
- The environment that would include overcoming the lack of precipitation (drought), and overall survival of species diversity.
- Ideas, institutions and structures of similar projects that lead to the progress of agriculture sector.

In the context of set goals research was carried out in the following aspects:

- On the environmental conditions of the region Herzegovina,
- On the natural characteristics of the area of research,
- On stage, means and methods of production of fruits, vegetables and table grapes,
- On determining the need for irrigation reference evapotranspiration (ETo) for each meteorological station was calculated by the method of FAO Penman-Monteith, thecomputer program CropWat (20 - annual averages from 1991 to 2010).

As reference indicators, data has been used from:

- The Federal Bureau of Statistics, the Federal Institute for Agriculture Sarajevo, Republic Institute of Statistics of RS, the data of municipal services.

Methodology of Study did not implyisolated (but did focal) contemporary approach based on:

Territorial approach that included the current state and development component in aspects of fruits, vegetables and table grapes in the municipalities of Mostar,Capljina, Citluk, Jablanica, Konjic, Neum, Prozor-Rama, Ravno, Stolac, Grude Ljubuski, Posusje Siroki Brijeg Kupres, Livno, Tomislav, Berkovici Bileca, Gacko, Istocni Mostar, Nevesinje, Trebinje, Ljubinje. Area of these municipalities is treated as a homogeneous production unit, which is characterized by agro-ecological cohesion with the same or similar historical and common values, including the principle of productivity.This territorial approach aims to encourage the growth of awareness on the part of the primary drivers of growth in other segments of agriculture and activates existing resources in achieving sustainable agricultural development.

"Bottom-up" (from bottom up) approach sought to encourage participation in the consideration of current problems and suggest future directions for development of this segment of agriculture,a method of participation of all interested parties (stakeholders)in the region of Herzegovina system.This would imply the inclusion of municipalities and other local, regional and other "partners" at the state level. This approach results in the direction of finding the best solutions that are presented in this study.

The partnership approach in considering all aspects and solutions in the progress of production of fruits, vegetables and table grapes from municipal agencies and stakeholders in the making of Study represents a very important segment. The study presents a model of organization that could significantly affect the institutional balance of the study area (region Herzegovina) and can be valences for the establishment of clusters.

Innovations in the Study are reflected in new ways to promote links between local and regional resources in the common characteristics that are of interest to the entire development, but still not "covered" by other development policies. Concept of Study offers activities and answers to the problems, weaknesses and opportunities of progress of production of fruits, vegetables and table grapes of studied areas, creating new products, new processes, markets and new forms of organization.

Integrated approach - Activities offered by study of local communities (municipalities) can be tightly linked and coordinated as a single entity. This means that the study took into account the possibility of establishing links with other segments of agriculture from the scope of crop production. The study is also based on the foundation and development of three-dimensional concept that includes strategy, area (territory) and partnership.

2. SOCIO-ECONOMIC IMPORTANCE OF FRUITS, VEGETABLES AND GRAPE SECTOR IN HERZEGOVINA REGION

The economy of Bosnia and Herzegovina is faced with many challenges and threats from the surroundings. Unfavorable demographic trends, the rapid development of science and technology, climate change, strengthening of international competition and the global crisis and recession are only some of the factors that affect the long term stability and competitiveness of B&H. Agriculture as part of the economy and society is closely associated with its development, in these conditions shows its importance and contribution to stabilization of the economy.

With the high participation in the GDP of B&H of 6.24% [1](2012.) agriculture today is a major economic activity. Although this share in the GDP is decreasing (8.3% in 2006 and 6.9% in 2011.),the agriculture sector has still very important role in the overall development. With the significant share in the foreign exchange, this sector employs 20% of the total number of employees in B&H. At the time when other sectors do not have capacities to receive work force because of the global economic crisis and recession, agriculture for already some time secures most significant number of jobs.

Since B&H is predominantly a rural country,the population is traditionally oriented on farming. The favorable geographic location and available natural resources are the main characteristics of this region, and also the most important precondition for agricultural production. In addition, the development of agriculture in B&H supports other factors such as relatively low labor costs, uncontaminated soil, and proximity to EU markets.

Agriculture in Bosnia and Herzegovina is at a much lower level than that could and should be.The potential for agricultural development is quite great, but underutilized. Almost half of the arable land is still not processed, and the average size of the property of used agricultural land is two hectares, which is far below the EU average (14.3 ha).Stagnating agricultural development is certainly contributedby climate change, which is reflected in the increase in average temperatures and more frequent extreme weather conditions.Drought, floods, and storms leave lasting effects on production and competitiveness, which is placed in front of the producers an additional request for a change in approach to agricultural production.The application of modern technical and technological measures and modernization of the sector in such conditions has been imposed as a necessity.

Due to the specific production "under the open sky," natural conditions are extremely important for agriculture.The final economic result of producersis largely determined by climate to which they have the least influence. Therefore, the right benefits of climate in the region of Herzegovina are most likely contributed to the fact that this is an area that in many agrarian aspects leads compared to other parts of Bosnia and Herzegovina.

Herzegovina is an extremely heterogeneous area whose environmental conditions are defined by the proximity of the sea, articulated mountainous relief and rivers. In this area there is presence of alternating mountain, moderately continental and Mediterranean belt, each with its own specificities, which has essentially determined the prevalence of certain types of production.

Neretva river valley experiences the influence of the Mediterranean climate, which north of Mostar passes into continental and in some higher areas experiences and features alpine climate. The largest part of Herzegovina still has a favorable climate with plenty of sunshine and heat, along with numerous rivers and lakesis suitable for the cultivation of various fruits and vegetables.The amount of rainfall is relatively high, but their irregular distribution makes the problem for agricultural producers. Specifically, while the period of winter and spring captures a large amount of rainfall, in summer they are small and negligible. With low rainfall and

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[1] *Gross domestic product by production and income approach 2005 - 2012, the Agency for Statistics of Bosnia and Herzegovina, available at: http://www.bhas.ba/tematskibilteni/Tematski% 20Bilten% 20BDP% 202005-2012.pdf*

extremely high temperatures during the summer, farming in Herzegovina, and particularly intense farming, is not possible without irrigation.

The basic requirements that affect the selection of crops that will be grown in a particular area are natural conditions: climate, relief, and soil.Given these conditions Herzegovina has exceptional qualities for the production of a variety of fruits and vegetables.

Fruits and vegetables, as well as their products are the main sources of nutrients and vitamins, and therefore have an important place in the diet of the population. Production and consumption of fruits in the world recorded a steady increase, and more and more organically produced fruit are requested.On the other hand, consumption of fresh fruit per capita in B&H is 2-3 times lower than in developed countries.Despite this, domestic production of fruits and vegetables still cannot meet the needs of B&H market, which is why we are forced to import these products, and the end result is a negative trade balance.

Compared to other areas, Herzegovina still leads in the production of fruits. The fruits that aremost common in cultivation are the peaches, apricots and cherries. In addition, in recent times there has been an increase in the cultivation of apples, pears and cherries and walnuts. There is more investing in producing pomegranate, fig and olive trees, while simultaneously an observed decrease of number of plum trees.

Plantation cultivation of fruit is still underrepresented in Herzegovina. Fruit growing, just like the viticulture in this area,is part of the tradition. Thus, in gardens throughout the area people generally raise orchards of mixed composition to settle the needs of families, while the eventual surpluses are placed for sale.

Orientation on commercial cultivation should certainly be a beacon for the future because Herzegovina has all the prerequisites for a successful production. This is primarily related to the production of early varieties of strawberries, cherries and peaches, and other fruits. The favorable climate in this area allows earlier ripening compared to the interior.On the other hand, the market has aconstant demand for fresh fruits, and in such conditions producers can achieve higher sales prices for early fruit and, ultimately, achieve better business results.

The economic effects of fruit production are significantly increased during the tourist season.Domestic and foreign tourists are increasingly looking for fresh and quality fruits, and in Herzegovina tour of the orchards and vineyards with the consumption of local products eventually will become an integral part of tourism.

Viticulturehas a longtraditionin Herzegovina. Whilein Bosnia, there are fewerareasunder vines, vine-growingismainlyconcentratedin the Herzegovina region.On the total area under the vineyards of 3450 ha[2], the wine grapes are dominant. The white variety are most present (71%) within which the most represented in the indigenous variety Zilavka (55%).The remaining 260 ha are composed of table grapes. Part of theproductionis exported toforeign markets, and most of itis usedfor consumptionin householdsengaged infarming. The area along the river Neretva has always had great potential for the production of the table grapes. Although inrecent times there is an increase incultivation, production is still notsufficient to meetdomestic demand, and thereforeour marketfor years willbesuitableforimport.

The Herzegovinaregiondominateswith thevegetable productioninB&H. Growing of vegetables is supported by goodnaturalconditions, but given thepotential, this region is far below theproductionpossibilities. Similar tofruit production,most of the production is done on the smaller areas close to the house. With the fulfillment of the needs of households, part of the production is intended for the market, and as a follow up activity that is an additional source of income.

Cabbage, onions, tomatoes, peppers and beans are the most common culture in outdoor cultivation in Herzegovina. In addition, vegetable production is mainly performed in protected facilities.In such areas production is organized in a way of alternating three, rarely four cultures throughout the year. Besides lettuce, tomatoes, cucumbers and peppers in this way production,

[2]*Cadaster vineyards Bosnia and Herzegovina, Federal Agro Mediterranean Institute*

but to a lesser extent, are done of string beans, green onions, spinach, mangold, squash and melons. Significant economic effects of production in greenhouses still cannot be commented on. Given that this is the most profitable form of production for small family farms and tare is the growing interest in this type of farming, it is realistic to expect the achievement of better results.

2.1. The importance and role of fruit and vegetable growing and viticulture in the socio-economic development of B&H

Fruit growing

Fruit growing is a very important professional and productive sector of agriculture, which contributes to a better use of production space, less suitable for some other branches of agricultural production.

The role of fruit is manifold: increasing the value of land, positive impact on the socio-economic conditions of the country, in terms of more jobs, higher living standards, and above all to improve the quality of nutrition of the population.The main task is the production of quality fruit, and fruit of different species and varieties of fruit trees.

Fruit is irreplaceable in the human diet, because it provides organisms with essential macro and micro nutrients required for normal functioning of the body and good health.

The importance of fruit is reflected in the possibility of its utilization in the fresh state, but also in the form of various products.Throughout the year we consume products from fruit: juices, compotes, jams, marmalade, sweet and dried fruit. The fruits of many species are used not only in food but also in the pharmaceutical and cosmetic industries.

Bosnia and Herzegovina is probably one of the few countries that have favorable conditions for various types of fruit production.With Mediterranean and moderate continental climate there is possibility of cultivating subtropical (Mediterranean) and continental fruits, from figs to winter varieties of apples and pears.

First of all, the Herzegovina region has comparative advantages for the cultivation of Mediterranean and subtropical fruits (figs, pomegranates, persimmons, Japanesemedlar, Japanese plums, almonds and sour cherry) and some continental (apple, pear, cherry, peach, plum, apricot, walnut, strawberry).In addition, in this region there is a tradition of growing early varieties of cherries, strawberries, apricots, peaches, figs, pomegranates, olives.

It should be noted that the Herzegovina area is with little arable land. Arable land is mostly found in the river valleys, karst fields, valleys, sinkholes. The lack of arable land commits to detailed planning and reasonable use of the same, which is particularly applicable to fruit production.The mere fact that fruit trees are multiannual crops indicates that the fruit production is a more complex branch of agricultural production in relation to other branches of agricultural production.

Therefore, the tradition should continue and also encourage more intensive cultivation of fruit species, which have historical and economic importance, and that can take a prominent place in conventional and organic fruit production.

Vegetable growing

In the total food production, vegetables and processed vegetables occupy an important place.Vegetable production is one of the most intense branchesof plant production. Agro-ecological specificity influences the development of agricultural production, including vegetable growing. In general it can be said that Bosnia and Herzegovina has favorable conditions for the production of vegetables, both in the northern and in the southern parts of the country. The development of vegetable production can significantly contribute to the economic development of the whole B&H. Size of yield influences profitability of the vegetable production.Yields of vegetables per unit area for all cultivated species are quite low and variable in some years.According to statistics in the 2011 and 2012, vegetables were planted on 78,000 hectares, which occupies 15% of the total sown area. However, due to large fluctuations in weather and the occurrence of drought vegetable production was unstable and had a negative trend in almost all cultures. In the 2011, there was an impairment of vegetable production to -10.68%.

Area Herzegovina is traditionally a vegetable producing region. Production takes place in smaller areas in the private sector with mixed production.The big problem is the supply of quality seeds and planting materials as well as selection of appropriate cultivars, for the success of the production adaptability of species and cultivars on meteorological environment in which it is grown is important.For some types of vegetables there are still older varieties present or non-selected local ecotypes.Local ecotypes give lower yields, but often have a high resistance to adverse environmental conditions. In order to develop intensive production in this area, with proper choice of species and varieties of shorter vegetation,it is possible to achieverotation of even three cultures per year.

In the lower southern parts of Herzegovina, which are influenced by the Mediterranean climate, it is possible to organize a year-round vegetable production. For the purpose of comparative advantages of the area primarily in terms of temperature and solar insolation, winter and early spring vegetable production dominates. In winter, the most commonly grown are cabbage and kale, cauliflower in lesser amount, while the early spring harvest bears early cabbage, early lettuce, early potatoes, onions, tomatoes, zucchini and cucumber for consumption in the fresh state.

A special place is occupied by an increase in competitive early vegetable production in protected areas that are commonly grown and economically most profitable types, such as: pepper, tomato and cucumber with interpolation of salad, bush bean and green onions. To achieve the high prices in the protected areas, very early cabbage hybrids are cultivated. Cultivation of vegetables in greenhouses provides a continuous supply of fresh market vegetables. It is estimated that fruit-bearing vegetables occupies more than 80% of the total vegetable production in Herzegovina. Using modern technologies of cultivation yields in protected areas are higher than in farming in open areas, and a growing number of producers are opting for this type of production. In the protected areas as well as on the bigger plots, irrigation system drop-by-drop is applied with the co-administration of water soluble fertilizers.

In northern and higher altitude parts of Herzegovina which are more influenced by continental climate is a common phenomenon of lower temperatures and winter vegetable production over large areas is not common. In the microclimate favorable parts of this area traditionally is grown late cabbage intended for pickling, late potatoes, onions and dry beans, and in warm seasons vegetables such as spinach, carrots, bush bean, and spinach. At higheraltitudes, in hilly and mountainous areas, there are conditions for successful production of seed potatoes because there is less infectious pressure in relation to the area of production of table potatoes.

The introduction of new technologies in the production of the aforementioned culture and rational use of resources of certain areas has significant priority in the agriculture region of Herzegovina. According to the strategy of agricultural development of HNC, projection for the overall increase in the area under a variety of vegetables has been made to 66.3% by 2016. There has been a trend of increasing consumption of vegetables to the increased consumer interest in healthy food. Certainly one of the directions of development of vegetable growing in this area needs to be organic vegetable production.

Viticulture

Share of agriculture in GDP in FB&H was 5.1% in the 2011, according to the Federal Bureau of Statistics. The share of agriculture in GDP shows that agricultural production is an important economic activity in the FB&H. According to estimates, the participation of employees in agriculture in the total number of employees in FB&H is around 13%, which indicates that agricultural production will have a significant number of jobs and existential carefor a large number of families. These data can be considered relevant for the region of Herzegovina as part of the FB&H.

The specificity of viticulture is in demand for certain specific environmental conditions in which it is possible to grow vines. Such conditions for growing grapes are present in Herzegovina.Wine-growing has a long tradition as evidenced by numerous archaeological excavations in the Neretva valley. Viticulture is one of the productive branches of agriculture. For the production of wine (without processing into wine and brandy) and table grapes, 10-15 times higher income per hectare is achieved compared to wheat production. Vineyards in this region have economic and traditional importance. There is also space for the expansion of this production, which is reflected in the raw agricultural land, the number of unemployed and the fact that we have not yet reached the pre-war areas planted with vines.

2.2. Participation of fruit growing, vegatable and viticulture in the agricultural sector of Herzegovina

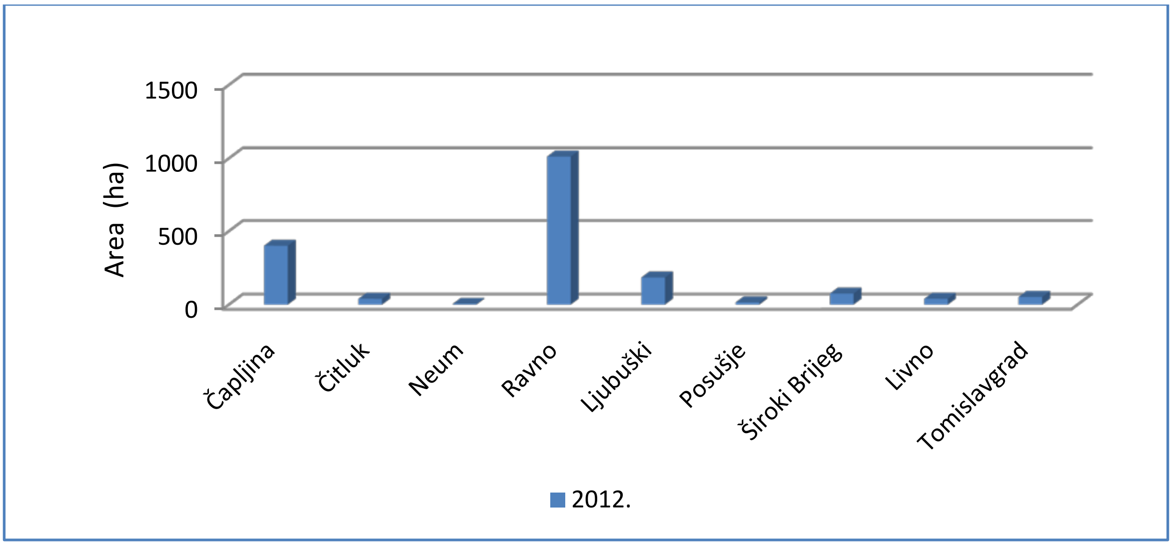
Fruit growing

Area Herzegovina is characterized by the production of different types of fruit Mediterranean (fig, pomegranate, kiwi, Japanese medlar), southern species (Japanese plum, almond, peach, cherry) and continental species (apple, pear, cherry, plum, apricot, walnut, strawberry).Description of the condition of fruit production in the Herzegovina municipalities of FB&H and RS is shown in graphs (*Graph 1 and Graph. 2*) and tables (*Tables 1 - Tab. 4*).

To assess the presence of certain species of fruit production in Herzegovina relevant data of the Federal Bureau of Statistics and the Republic Institute of Statistics were used.

Due to incomplete statistics for cultivated fruit species by individual municipalities and years, as well as discrepancies in the statistical monitoring of municipalities in FB&H and RS,it is not possible to provide a uniform view of the representation of certain types of fruits in all Herzegovina municipalities that were included in this analysis. In some municipalities there are no data on the total yield and yield per tree.

The graph (*Graph 1*) shows the representation of the total area under orchards in the area of Herzegovina, FB&H municipalities in the 2012.

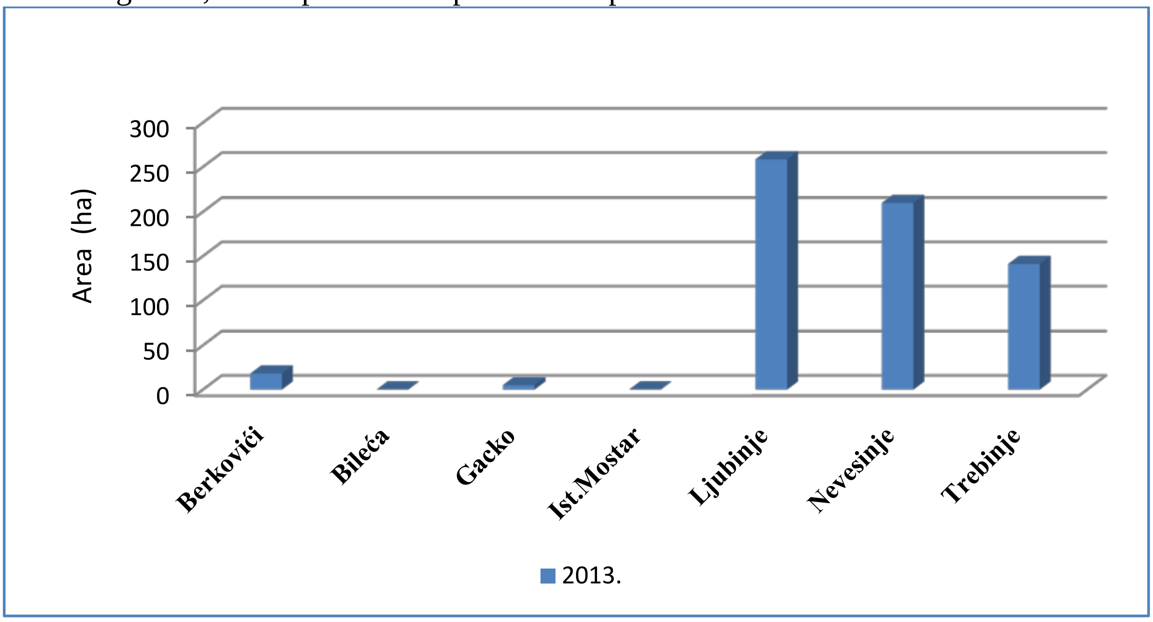


Graph 1: Total area under orchards in the area of Herzegovina, FB&H municipalities in the 2012 (Source: Competent municipal services)

According to municipal data the largest share of the area under orchards in the total agricultural land in 2012 had following municipalitities:

- Ravno 1012 ha (4.89% of the total agricultural land of the municipality)
- Capljina 400 ha (2.96% of the total agricultural land of the municipality)
- Ljubuski 186 ha (1.05% of the total agricultural land of the municipality)

The following graph (*Graph 2*) shows a representation of the total area under orchards in the area of Herzegovina, the Republic of Srpska municipalities in the 2013.



Graf. 2: The total area under orchards in the area Herzegovinia municipalities RS 2013 (Source: Competent municipal services)

According to municipal data the largest share of the area under orchards in the total agricultural land in the 2013 had municipalities:

- Ljubinje 258.5 ha (1.53% of the total agricultural land of the municipality)
- Nevesinje 210 ha (0.89% of the total agricultural land of the municipality)
- Trebinje 141 ha (0.72% of the total agricultural land of the municipality)

From the above chart, statistical data it is evident that the proportion of fruit area in total agricultural land is low, indicating that growing fruit trees in this area is not at the level where it could be.

Tabular data (*Tab 1*) show the presence of species of fruit: apples, pears, plums and walnuts in production in the form of total return (t) and yield per tree (kg / tree) for all municipalities of Herzegovina region.

Table 1: Yields of analyzed fruit species in the Herzegovina on the arera of FB&H municipalities (2010-2012)

Municipality	Year	Apple		Pear		Plum		Wallnut	
		Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	prinos (kg/tree)
Capljina	2010	24	0,4	6	30,0	300	50,0	2	5,0
	2011	455	3,4	6	30,0	330	55,0	20	5,0
	2012	569	3,8	8	15,0	360	60,0	-	-
Citluk	2010	9	10,0	5	9,0	12	12,0	10	8,0
	2011	5	5,0	2	4,0	6	6,0	3	2,0
	2012	5	4,0	3	4,0	6	5,0	3	2,0
Mostar	2010	49	6,2	30	5,2	68	8,9	37	7,2
	2011	57	7,5	30	5,6	66	8,8	32	7,1
	2012	30	4,0	20	3,8	32	4,2	28	6,2
Jablanica	2010	35	10,0	-	-	300	15,0	36	20,0
	2011	53	15,0	-	-	300	15,0	36	20,0
	2012	18	5,0	6	2,5	-	-	2	1,0
Konjic	2010	425	5,0	360	5,0	1000	5,0	63	3,0
	2011	595	7,0	504	7,0	1400	7,0	84	4,0
	2012	255	3,0	144	2,0	200	1,0	21	1,0
Neum	2010	1	5,0	1	4,0	0	7,0	0	5,0
	2011	1	5,0	1	4,0	0	7,0	0	5,0
	2012	1	5,0	1	3,0	0	7,0	0	5,0
Prozor-Rama	2010	230	20,0	81	13,0	6412	20,0	34	8,0
	2011	400	20,0	91	13,0	6600	20,0	28	8,0
	2012	15	2,0	8	1,3	504	2,0	3	0,8
Ravno	2010	1000	10,0	-	-	20	10,0	-	-
	2011	2000	20,0	-	-	20	10,0	-	-
	2012	600	10,0	-	-	-	-	-	-
Stolac	2010	92	20,0	-	-	350	25,0	8	12,0
	2011	160	20,0	-	-	363	25,0	-	-
	2012	160	20,0	-	-	363	25,0	-	-
Grude	2010	42	6,0	12	4,0	16	3,0	19	5,0
	2011	42	6,0	16	5,0	26	4,0	20	5,0
	2012	40	5,0	14	4,0	20	3,0	18	4,0
Ljubuski	2010	77	20,0	14	12,0	20	13,0	39	17,0
	2011	77	20,0	13	11,0	29	14,0	38	17,0
	2012	76	20,0	13	11,0	21	10,0	37	17,0

Posusje	2010	8	1,7	1	0,5	6	0,7	4	3,0
	2011	7	1,7	1	1,2	9	0,8	4	3,0
	2012	3	0,5	0	0,2	6	0,5	4	3,0

Source: Federal Bureau of Statistics

Table 1: continued

Municipality	Year	Apple		Pear		Plum		Wallnut	
		Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)
Siroki Brijeg	2010	-	-	-	-	-	-	-	-
	2011	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-
Kupres	2010	-	-	-	-	-	-	-	-
	2011	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-
Livno	2010	12	3,5	3	3,2	55	2,5	21	3,0
	2011	15	4,5	4	3,5	86	4,0	35	5,0
	2012	8	2,3	2	1,8	44	2,0	18	2,5
Tomi-slavgrad	2010	45	5,0	20	5,0	45	5,0	15	10,0
	2011	50	5,0	20	5,0	50	5,0	44	4,0
	2012	30	3,0	12	3,0	30	3,0	33	3,0

Source: Federal Bureau of Statistics

From the statistical data (*Tab 1*) it is obvious that apple production is represented in all analyzed Herzegovinian municipalities of FB&H (except the municipalities for which statistical data does not exist). The largest apple production through the three analyzed years was recorded in the municipalities Ravno, Konjic, Capljina and Prozor-Rama. The lowest representation of apple fruit production was recorded in the municipality of Neum, Citluk and Posusje.In the 2011 the largest apple production is recorded in the municipality Ravno in the amount of 2000 t.From the statistical data there is a noticeable drop in apple production in areas of most of the analyzed municipalities in 2012 compared to 2010, except Capljina and Stolac municipality where there has been a growth in production. The yield of apples per tree ranged from 0.4 kg / tree in the municipality Capljina to 20 kg / tree in municipalities Prozor-Rama, Stolac and Ljubuski. Very low yields of apples per tree were recorded in the municipalities Posusje, Grude, Neum, Konjic, Mostar, Citluk, Capljina, Livno, Tomislavgrad.

Of the analyzed species of fruit, pear fruit is most represented in the total fruit production in the municipality of Konjic and Prozor-Rama for the relevant time period, (*Tab 1*).The lowest pear production was recorded in the municipalities of Posusje, Neum and Jablanica.The highest production of pears is recorded in the 2011 in the municipality of Konjic and totaled 504 t. There is a drop in the total production of pear fruit production for the period (2010-2012).Yield per pear tree in most municipalities is low, except for the municipality Capljina, where it amounted to 30 kg / tree. Also notable is the decline in yields per pear tree in most of the analyzed municipalities.

The biggest plum production was in the municipalities of Prozor-Rama, Konjic, Capljina and Stolac, while the lowest production was in the municipality of Neum, Citluk and Posusje.Production of 6600 t was recorded in the area of Prozor-Rama in the 2011. Otherwise, it should be mentioned that the area is known for its traditional breeding of plums. It should also be noted that the area of Stolac and Capljina municipality recorded growth in production of plums for the observed time period (*Tab 1*). The yield per tree plums ranged from 0.5 kg / tree in the municipality of Posusje to 60 kg / tree in the Capljina municipality.

Among the analyzed species of fruit, walnut is the most represented species in the total fruit production, but no less valuable. The highest production of walnuts is recorded in the Konjic municipality in the 2011 and 2010, while the highest yield of walnuts per tree was recorded in the municipality of Jablanica 20 kg / tree in the same time period. No significant production of walnuts was recorded in the municipality of Neum (*Tab 1*).

Tabular data (*Tab. 2*) show the presence of species of fruit: peaches, cherries and apricots in the production in the form of total yield (t) and yield per tree (kg / tree) for all municipalities of Herzegovina in the FB&H.

Table 2: Yields of analyzed fruit species in the Herzegovina municipalities of FB&H (2010-2012)

Municipality	God.	Peach		Sweet Cherry		Cheery		Apricot	
		Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)
Capljina	2010	4957	19,1	91	13,2	20	20,0	93	30,0
	2011	5798	19,0	158	14,0	50	25,0	158	45,0
	2012	5310	18,6	150	12,8	50	25,0	158	45,0
Citluk	2010	8	10,0	15	15,0	15	5,0	3	7,0
	2011	5	4,0	17	16,0	24	6,0	3	8,0
	2012	4	4,0	18	14,0	23	5,0	4	6,0
Mostar	2010	83	5,0	532	8,5	51	5,4	18	4,0
	2011	88	5,2	564	10,5	55	6,7	26	5,9
	2012	63	3,5	606	11,0	61	6,0	30	6,8
Jablanica	2010	-	-	25	10,0	-	-	8	10,0
	2011	-	-	25	10,0	10	9,5	8	10,0
	2012	-	-	30	12,0	-	-	-	-
Konjic	2010	-	-	105	5,0	-	-	-	-
	2011	-	-	105	5,0	-	-	-	-
	2012	-	-	84	4,0	-	-	-	-
Neum	2010	1	7,0	1	4,0	-	-	3	5,0
	2011	1	7,0	1	4,0	-	-	3	5,0
	2012	0	5,0	1	4,0	-	-	3	5,0
Prozor-Rama	2010	1	8,0	81	18,0	20	15,0	-	-
	2011	2	8,0	90	18,0	57	15,0	-	-
	2012	0	0,8	14	3,0	4	2,0	-	-
Ravno	2010	1050	15,0	150	10,0	5	10,0	-	-
	2011	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-
Stolac	2010	1424	20,0	540	30,0	84	20,0	313	25,0
	2011	1444	20,0	570	30,0	90	20,0	384	30,0
	2012	1444	20,0	570	30,0	90	20,0	320	25,0
Grude	2010	8	4,0	35	5,0	9	3,0	7	6,0
	2011	12	6,0	42	6,0	9	3,0	6	5,0
	2012	12	5,0	42	6,0	9	3,0	6	5,0
Ljubuski	2010	113	19,0	87	19,0	20	14,0	34	15,0
	2011	120	20,0	99	20,0	29	20,0	35	15,0
	2012	115	19,0	94	19,0	28	14,0	35	15,0
Posusje	2010	-	-	22	8,0	4	4,0	-	-
	2011	-	-	20	7,0	3	7,0	-	-
	2012	-	-	14	5,0	2	2,0	-	-

Source: Federal Bureau of Statistics

Table2:continued

Municipality	God.	Peach		Sweet cherry		Cheery		Apricot	
		Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)
Siroki Brijeg	2010	-	-	-	-	-	-	-	-
	2011	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-
Kupres	2010	-	-	-	-	-	-	-	-
	2011	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-
Livno	2010	-	-	9	10,0	1	7,0	-	-
	2011	-	-	10	11,0	1	7,0	-	-
	2012	-	-	8	8,8	1	5,6	-	-
Tomi-slavgrad	2010	-	-	2	5,0	1	2,5	-	-
	2011	-	-	2	5,0	1	2,5	-	-
	2012	-	-	2	5,0	1	2,5	-	-

Source: Federal Bureau of Statistics

The area of Capljina and Stolac municipality have seen the largest peach production for all three observed years. In 2011, peach production ranged from 1,444 t in the area of Stolac to 5798 t in the area of the Capljina municipality. The lowest value of peach production was recorded in the municipality of Neum and Prozor-Rama (Tab. 2).The highest yield of peaches per tree was recorded in Stolac and amounted to 20 kg / tree.

Sweet cherry is mostly grown in the municipalities of Mostar and Stolac (Tab. 2)followed by the municipality Capljina, Konjic and Ljubuski. In the municipality of Mostar production has been recorded of 606 t of sweet cherries in the 2012, which is the highest value recorded for the observed period. TheMostar area is the traditional territory of growing sweet cherries. The lowest representation in sweet cherry production is recorded in the municipality of Neum, Tomislav and Livno. The highest yield of sweet cherries per tree was recorded in Stolac of 30 kg / tree.

The tabular data (*Tab. 2*) shows that the most cherries are grown in the municipalities of Stolac, Mostar and Capljina, and least in the area of Livno, Tomislavgrad, Ravno and Jablanica. The largest cherry production of 90 t was recorded in the 2011 and 2012 in the area of Stolac, while the highest yield of cherries per tree was recorded in the municipality of Capljina 25 kg / tree. Also, it should be noted that the increased production of cherries is in the municipalities of Stolac, Mostar, Citluk and Capljinathrough the observed time period.

The dominant and by far the largest apricot production in comparison to other municipalities is recorded in the municipalities of Stolac and Capljina. In the municipality of Stolac in 2011 apricot production amounted to 384 t, while the yield per apricot tree ranged from 25 to 30 kg / tree. In other Herzegovina municipalities in FB&H, apricot was less or not at all represented in the production, which can be explained by its specific climatic requirements (*Tab. 2*).

Tabular data (*Tab. 3*) show the presence of fruit species: almonds, tangerines, lemons, figs, olives and the production of it in the form of total production / yield (t) and number of fruit trees in Bosnia and Herzegovina. Since these fruit species belong to the Mediterranean fruit species, which have the specific requirements of the climatic growing conditions, the accompanying statistical data (*Tab. 3*) is related to the area of Herzegovina municipality of Bosnia and Herzegovina, in which the aforementioned types and mainly grown.

Table 3: Yields of analyzed fruit species in the Herzegovina municipalities in the area of B&H (2010-2012)

Vocna vrsta	2010		2011		2012	
	Number of fruit bearing trees	Production /yield (t)	Number of fruit bearing trees	Production /yield (t)	Number of fruit bearing trees	Production /yield (t)
Almond	12.528	80	12.618	86	10.888	49
Tangerine	3.500	26	3.530	23	3.100	16
Lemon	3.580	22	3.250	14	2.800	7
Fig	62.270	725	63.390	741	67.400	715
Olive	16.055	100	31.300	153	33.080	153

Source: Appropriate municipal department

From the accompanying statistical data (*Tab. 3*) it is evident that fig tree is the most common in fruit production of Mediterranean species with the highest number of trees followed by the olives, almonds, tangerine and lemon.For the production in (t), the fig tree is in the first place, followed by olive, almond, tangerine and lemon. For all of these types there is noticeable drop in production (t) in 2012 compared to the previous two years.

Tabular data (*Tab. 4*) shows the presence of species of fruit: apples, pears, plums and cherries in the production in the form of total yield (t) and yield per tree (kg / tree) in all Herzegovina municipalities of the Republic of Srpska.

Table 4: Yields of analyzed fruit species in the Herzegovina municipalities in RS (2010-2012)

Municipality	Year	Apple		Pear		Plum		Cherry	
		Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)	Total yield (t)	Yield (kg/tree)
Berkovici	2010	85	10,0	30	15,0	48	8,0	50	20,0
	2011	20	12,0	41	17,0	70	10,0	60	20,0
	2012	18	10,0	31	11,9	40	5,0	47	15,0
Bileca	2010	37	10,0	32	9,0	106	11,0	69	19,0
	2011	44	12,0	35	10,0	144	15,0	72	20,0
	2012	40	10,9	35	10,0	134	14,0	76	21,0
Gacko	2010	5	38,0	1	42,0	17	41,0	-	-
	2011	5	31,4	1	41,7	16	38,1	-	-
	2012	8	32,0	1	25,0	15	35,7	0	0,0
Istocni Mostar	2010	-	-	-	-	-	-	-	-
	2011	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-
Ljubinje	2010	105	3,7	2	10,0	8	10,0	20	10,0
	2011	45	10,0	2	10,0	8	10,0	90	1,3
	2012	45	10,0	2	10,0	8	6,2	130	1,6
Nevesinje	2010	42	3,0	21	3,0	132	4,0	0	0,0
	2011	15	1,0	15	2,0	70	2,0	0	0,0
	2012	75	5,0	29	4,0	165	5,0	1	3,9
Trebinje	2010	190	8,0	12	4,0	66	5,0	116	4,2
	2011	156	5,7	12	4,0	49	4,0	111	4,0
	2012	145	1,1	6	1,9	38	3,0	50	2,5

Source: Republic biro for statistics of RS

Apple participates in the total fruit production in all analyzed areas of the Republic of Srpska municipalities, (*Tab. 4*). The largest quantity of apple was produced in the municipalities of Trebinje, Ljubinje and Berkovici in a given time period, from 2010to 2012. The lowest quantities of apples were produced in the municipality of Gacko - only 5 t. The largest apple production is recorded in the municipality of Trebinje, 190 kg / tree in 2011. The highest yield of apples per tree was in 2010 in the municipality of Gacko and was 38 kg / tree.

Pear production is represented in all the municipalities of the Republic of Srpska, but in very small quantities (*Tab. 4*). Thehigest production of pears was observed in Berkovica for a given time period and it was 41 kg / tree and in the municipality of Bileca 35 kg / tree.

In the territory of the analyzed municipalities of Republic of Srpska, plum occupies an important place in the total fruit production. Plum production ranged from 8 tin Ljubinje to 165 t in Nevesinje within the observed three years, (*Tab. 4*). The yield per plum tree ranged from 2.0 to 41 kg / tree.

The largest cherry production was observed in the area of Ljubinje, and the lowest in the area of Nevesinje. In 2012, cherryproduction amounted to 130 t in the municipality of Ljubinje. In the municipality of Trebinje cherry production has a significant share in fruit production with the fact that 2012 had a decrease in production over the previous two years (*Tab. 4*). The highest cherry yield was recorded in Berkovici of 20 kg / tree in the 2010 and 2011. Cherry, like pear,is a less represented species in the total fruit production of analyzed Herzegovina municipalities of Republic of Srpska.

From the above statistics it can be concluded that the production of apples is represented in all analyzed Herzegovina municipalities of FB&H (except the municipalities for which statistical data does not exist).Among the analyzed species of fruit by yield achieved, walnutis least represented species in the total fruit production.By achieved total production or yield in (t) in all the analyzed municipalities in the FB&H in the period 2010 to 2012 sequence of fruit species is as follows: plum, apple, peach, sweet cherry, cherry, walnut and apricot. Peach and apricot in some municipalities are not represented at all in the production, which is most likely due to their specific requirements according to climatic conditions. Mediterranean fruit species are present in fruit production in the southern parts of Herzegovina municipalities, of which the most common is fig, and more recently the production of olive is growing.

From the statistical data it is noticeable that the total fruit production in the area of Herzegovina municipalities of Republic of Srpska most common production is of apple and plum, followed by cherry and pear. In all three analyzed years, the apple is the most common of the total fruit production in the municipality of Trebinje and Ljubinje and plums in the municipality of Bileca and Nevesinje. Cherry was slightly more frequent in the total fruit production in the municipality of Trebinje and Ljubinje, while the pear was the least represented in the total fruit production in the territory of the Republic of Srpska municipalities.

Observed through three years (2010-2012), one can notice that the production of apples in the municipality of Trebinje, Ljubinje and Berkovici has decreased, while production of plums did not record such a reduction in the municipalities of Bileca and Nevesinje. The municipality of Gacko has the lowest representation of all analyzed fruit species in total fruit production in relation to all the other Herzegovina municipalities of the Republic of Srpska.

It should be noted that the recorded decline in yields (t), and the yield per tree (kg / tree) for all analyzed fruit species in the area of Herzegovina municipalities of FB&H as well as in the Republic of Srpska in the 2012 compared to 2010 and 2011were influenced by a long period of drought in the vegetation year.

The attached statistical data indicate a low level of fruit production in the analyzed area ofHerzegovinia municipalities in FB&H, as well as Republic of Srpska.Possible causes of such a situation in fruit production are: extensive or semi intensive way of growing fruit species, nonexistent or inadequate application of agro-technical measures and pomotechnical, unhealthy and substandard seedlings, small and fragmented land holdings, poor technical equipment of farms, outdated production technology, symbolic use of irrigation systems and others. Additionally, fruit production is burdened with difficulties regarding the lack of capacity for treatment and processing of fruits. Fruit in these areas is mainly used in the fresh state. A small portion of fruit is used to produce fruit juice, jam, brandy, drying, mainly within the family farms.

Vegetable production

The analysis of the yield of vegetables by individual Herzegovina municipalities can be seen that the yields per unit of area are very low compared to the production possibilities. The reason for such low yields is a small share of commercial production.The increase in yield is often not proportional to the increase in surface area due to adverse weather conditions. The negative effects of the long dry periods followed by high temperatures due to global climate change can be prevented with quality irrigation system. The need for development of modern irrigation systems was highlighted in the current strategies of the Federation of B&H and the Republic of Srpska in the area of agriculture.

Yields are higher in vegetable cultivation in greenhouses where more producers are using modern technological processes. Unlike the Republic of Srpska, theFederation of Bosnia and Herzegovina has no official statistical monitoring of vegetable production in greenhouses. The largest area of production under protected areas in Bosnia and Herzegovina is located in the Herzegovina area of HNC. According to estimates the production in this cantonis organized on 360 hectares of protected areas, and shows that the yields of some varieties of vegetables growing in relation to the statistics presented.

The status of vegetable production in the Herzegovina municipalities is shown using the data of the Federal Statistical Office and the Republic institute of statistics RS. It should be noted that difficulties in analyzing the data is due to the lack or incomplete statistical data for some municipalities, years of productionand the types of vegetables. Condition of vegetable production in the Herzegovina municipalities in B&H (2010-2012) and the municipalities in the RS (2013) is presented in tables (Tab. 5 and Tab. 6).

Because of different statistical monitoring, a uniform view cannot be providedon the situation of vegetable production in 23 Herzegovina municipalities which were analyzed. In 2011, the municipalities of the Herzegovina-Neretva Canton under vegetableproduction were 11.01%, in the municipalities of West Herzegovina Canton 4.79%, while the municipalities of the Herzegbosnia canton under vegetableproduction were 2.26% of the total sown area under vegetables in FB&H. In the same year, from the total sown area, under vegetables following share has been registered in the municipality Berkovici 25.00%, 45.43% Bileca, Gacko 23.00%, 20.51% of Istocni Mostar, Ljubinje 16.14%, 23.24% Nevesinje Trebinje and 44.38%.

In accordance with the biological characteristics as well as soil and climatic conditions of the cultivating areas, noticeable distinctionin the representation of vegetable species, and thus the differences in yield.

Table 5: Areas and yields of selected vegetables in the Herzegovina municipalities of FB&H (2010-2012)

Municipality	Year	Potato		Beens		Onion		Cabbage		Tomato	
		area (ha)	yield (t/ha)	area (ha)	yield (t/ha)	area (ha)	yield (t/ha)	area (ha)	yield (t/ha)	area (ha)	yield (t/ha)
Capljina	2010	120	30,0	3	-	3	30,0	100	45,0	60	50,0
	2011	200	30,0	5	-	5	25,0	120	45,0	80	50,0
	2012	200	25,0	-	-	7	30,0	100	48,0	100	50,0
Citluk	2010	400	9,0	25	-	30	3,0	20	8,0	20	13,0
	2011	410	7,0	25	-	32	2,0	13	4,0	21	10,0
	2012	420	6,0	2	1,0	33	20,0	15	3,5	22	10,0
Mostar	2010	420	11,0	57	2,5	67	7,3	60	20,0	69	7,0
	2011	754	12,2	128	2,7	109	7,8	58	22,0	90	7,2
	2012	762	8,5	92	1,7	112	4,8	52	18,0	92	3,0
Jablanica	2010	110	12,0	10	2,0	30	8,0	35	8,0	20	8,0
	2011	115	12,0	10	4,0	25	6,0	35	8,0	25	8,0
	2012	115	10,0	5	1,0	30	5,0	30	8,0	25	10,0
Konjic	2010	210	10,0	30	1,0	100	10,0	85	25,0	60	30,0
	2011	220	15,0	15	1,2	150	11,0	13	26,0	87	87,0
	2012	225	9,0	10	0,8	155	16,0	10	18	91	37,0
Neum	2010	65	7,0	11	1,0	11	7,0	6	8,0	8	5,0
	2011	65	8,0	11	1,0	11	7,0	6	8,0	8	9,0
	2012	65	6,0	4	-	10	8,0	6	8,0	7	5,0
Prozor-Rama	2010	340	25,0	13	1,5	28	20,0	18	16,0	34	25,0
	2011	340	25,0	23	1,5	28	20,0	18	16,0	35	25,0
	2012	200	12,5	10	0,5	25	10,0	20	8,0	30	12,0
Ravno	2010	20	12,0	2	-	5	6,0	-	-	2	18,0
	2011	10	14,0	2	-	2	6,0	3	-	2	20,0
	2012	30	1,4	-	-	4	0,6	-	-	3	10,0
Stolac	2010	180	9,0	2	2,5	8	6,0	10	8,2	8	8,8
	2011	190	10,0	3	2,5	7	6,0	11	8,2	9	7,0
	2012	190	10,0	2	2,5	7	6,0	11	8,2	9	8,8
Grude	2010	380	4,5	15	2,0	25	3,0	20	4,0	20	3,0
	2011	410	4,5	20	2,0	15	4,0	25	5,0	15	4,0
	2012	390	4,5	15	2,0	20	3,5	22	5,0	19	4,0
Ljubuski	2010	310	16,5	20	1,5	130	8,4	90	18,8	160	11,0
	2011	305	18,0	22	1,5	130	8,5	82	20,0	155	14,0
	2012	300	18,0	15	1,5	125	8,2	70	20,0	155	13,0
Posusje	2010	340	1,5	22	1,7	20	2,5	130	2,5	4	2,0
	2011	341	1,6	20	1,7	20	2,5	132	2,3	3	2,0
	2012	342	0,9	14	1,3	20	1,9	130	1,4	3	1,7
Siroki Brijeg	2010	-	-	-	-	-	-	-	-	-	-
	2011	-	-	-	-	-	-	-	-	-	-
	2012	-	-	-	-	-	-	-	-	-	-

Table 5:continued

Municipality	Year	Potato		Beens		Onion		Cabbage		Tomato	
		area (ha)	yield (t/ha)	area (ha)	yield (t/ha)	area (ha)	yield (t/ha)	area (ha)	area (ha)	yield (t/ha)	area (ha)
Kupres	2010	20	10,0	-	-	0	3,0	2	8,0	-	-
	2011	18	10,0	-	-	0	3,0	2	8,0	-	-
	2012	18	10,0	-	-	1	3,0	2	8,0	-	-
Livno	2010	220	10,5	14	2,2	15	4,8	30	16,0	3	4,0
	2011	225	11,0	12	2,2	19	4,8	35	16,0	4	4,0
	2012	230	8,0	14	1,6	15	3,4	33	11,0	3	2,8
Tomi-slavgrad	2010	130	25,0	2	1,5	4	30,0	50	30,0	1	20,0
	2011	140	25,0	4	1,5	5	30,0	56	30,0	1	20,0
	2012	170	15,0	2	1,2	5	20,0	60	20,0	1	-

Source: Federal statistics agency

By analyzing the statistical data for all displayed municipalities it can be concluded that the largest area is occupied by potatoes, cabbage and onions. The municipalities in the Federation of B&H have largely increased area under all reference types in the 2011 and 2012 compared to 2010.However, it can not be said for the yield, which have stagnated or has been in a decline in yields in these years.The last two years have been assessed as unfavorable becasue of climate, the result was underperformance of yield.

A comparative view of the negative effects of climate conditions on the yield of potatoes in all analyzed municipalities is presented in graph 3. Largest decline in yields of potatoes is evident in the municipalities of Nevesinje, Prozor-Rama and Tomislavgrad where yields in the 2012 almost halved compared to the previous year.

Progress has been made in the production of seedlings that are produced using modern technological processes. The containers filled with special substrates successfullyproduced seedlings of lettuce, cabbage, cucumbers, watermelons, melons, peppers and tomatoes. Container seedling production is particularly important in hybrid varieties in which the work of expensive seeds are important to develop seeds from each plant.

The largest vegetable production areas are occupied by peppers and tomatoes. These are cultures in which significant shifts in production can be seen. With tomatoes there are increases in usageof bumblebees instead of hormone for pollination and pheromones for hunting harmful insects, which are characteristics of organic production. Bumblebees in relation to bees are more tolerant of temperature fluctuations, and their activity is weaker at extreme temperatures.

In open areas an increase in the production of watermelon is evident. According to the available municipal data for the year 2012 most watermelons were produced in the municipalities of Ljubuski - 2275 t (35 t / ha) and Capljina 1200 t (48t/ha). In the production of watermelon and tomatoes using grafted seedlings is on the rise, which has a number of advantages over conventionally produced seedlings, resulting in safer and higher yield.

Table 6: State of production of selected vegetables in the Herzegovina municipalities in the RS (2013)

Municipality	Potato			Cabbage and kale			Tomato			Paprika			Onion		
	area (ha)	production (t)	yield (t/ha)	area (ha)	production (t)	yield (t/ha)	area (ha)	production (t)	yield (t/ha)	area (ha)	production (t)	yield (t/ha)	area (ha)	production (t)	yield (t/ha)
Berkovici	50	300	6,0	4,0	20,0	5,0	5,0	50,0	10,0	20,0	400,0	20,0	3,0	36,0	12,0
Bileca	365	1332	3,6	23,0	110,0	4,8	7,0	18,0	2,6	6,0	14,0	2,3	17,0	35,0	2,1
Gacko	79	190	2,4	4,0	6,0	1,5	4,0	3,0	0,8	3,0	2,0	0,7	6,0	8,0	1,3
Istocni Mostar	15	120	8,0	1,0	50,0	50,0	1,0	80,0	80,0	1,0	20,0	20,0	1,0	5,0	5,0
Ljubinje	40	480	12,0	1,0	10,0	10,0	1,0	15,0	15,0	1,0	15,0	15,0	7,0	91,0	13,0
Nevesinje	273	6781	24,8	114,0	830,0	7,3	3,0	3,0	1,0	2,0	1,0	0,5	107,0	545,0	5,1
Trebinje	160	1280	8,0	30,0	450,0	15,0	30,0	300,0	10,0	10,0	60,0	6,0	35,0	280,0	8,0

Municipality	Beans			Cucumber			Watermelon			Melon			Salad		
	area (ha)	production (t)	yield (t/ha)	area (ha)	production (t)	yield (t/ha)	area (ha)	production (t)	yield (t/ha)	area (ha)	production (t)	yield (t/ha)	area (ha)	production (t)	yield (t/ha)
Berkovici	1	2	2,0	0,5	0,5	1,0	1,5	90,0	60,0	0,5	10,0	20,0	1,0	0,5	0,5
Bileca	7	2,5	0,4	4,0	6,0	1,5	0,0	0,0	0,0	1,0	3,0	3,0	3,0	7,0	2,3
Gacko	7	11	1,6	6,0	4,0	0,7	0,0	0,0	0,0	0,0	0,0	0,0	3,0	2,0	0,7
Istocni Mostar	1	10	10,0	1,0	40,0	40,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Ljubinje	1	1	1,0	1,0	11,0	11,0	2,0	24,0	12,0	1,0	20,0	20,0	0,0	0,0	0,0
Nevesinje	10	9	0,9	2,0	2,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0	5,0	5,0	1,0
Trebinje	14	35	2,5	5,0	20,0	4,0	15,0	225,0	15,0	10,0	120,0	12,0	5,0	25,0	5,0

Source: Federal Office for Agriculture

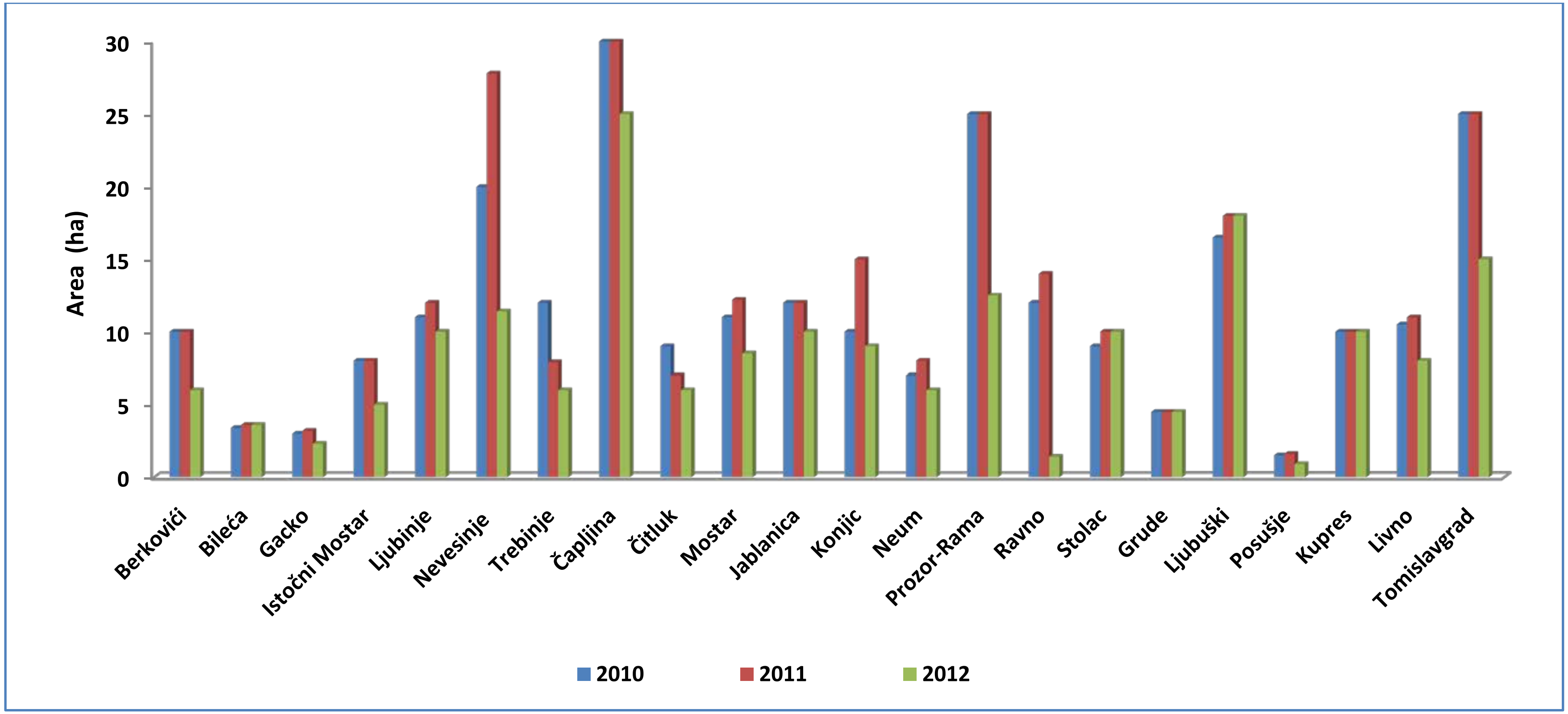


Figure 3: The yield of potatoes in the Herzegovina municipalities (2010-2012)
Source: Federal Bureau of Statistics (no data for the municipality Siroki Brijeg), Republic Srpska Institute of Statistics*

Viticulture

The total production of grapes and wine in B&H and FB&H takes place in Herzegovina, in the area of following municipalities: Mostar, Capljina, Citluk, Neum, Prozor, Ravno, Stolac, Grude, Ljubuski, Siroki Brijeg and Trebinje. Participation of viticulture in agricultural production in the territory of FB&H is shown through the ratio of the total planted area in agricultural arable land (*Tab. 7*), and can be displayed within relationships of the various other parameters.

Table 7: Share of vineyard area in total cultivated agricultural areas in the FB&H

	2010. (000 ha)	2011. (000 ha)	2010. %	2011. %
Fields and gardens	398	390	56,8	56
Orchards	44	44	6,3	6,3
vineyards	**5**	**5**	**0,7**	**0,7**
Meadows	254	257	36,2	37,0
Total arable soil	**701**	**696**	**100**	**100**

Source: Federal Statistical Office

In both observed years, proportion of the area planted with vines in the total cultivated agricultural land in the territory of FB&H is 0.7%.

Table 8: Production of grapes per canton in the FB&H for the 2011 and 2012

Canton	Yield 2011. (t)	Yield 2012. (t)
Unsko-sanska	9	31
Posavska	43	32
Tuzlanska	39	34
Zenicko-dobojska	29	25
Bosansko-podrinjska	37	–
Srednjobosanska	1	4
Hercegovacko-neretvanska	15021	19579
Zapadnohercegovacka	3439	3229
Sarajevo	3	3
Hercegbosanska	0	0
TOTAL	18621	22937

Source: Federal Statistical Office

According to the Federal Bureau of Statistics, presented in Table 8, in the region of Herzegovina (no data for Siroki Brijeg and Trebinje) in 2011 and 2012, production of the grapes was 41,268 t. The average price of grapes in those two years was 1 BAM / kg, which tells us that the wine-growing sector, in Herzegovina in the 2011 and 2012, produced 41,268,000.00 BAM of new value.

2.3. Types of agriculture cultures in the Herzegovina region, which production has economic production effectiveness

2.3.1. Fruits (apple, pear, plum, peach, apricot, sweet cherry, cherry, almond, walnut fig, pomegranate, olive, blackberries, raspberries, strawberries)

Understanding of the relations between the environmental conditions of specified area and certain types of substrates and varieties of fruit trees is essential to exploit the comparative advantages of the area for growing certain species, fruit tree varieties.

Ecological conditions are fundamental determinants that indicate whether a certain production area can even grow some fruit species, then if certain fruit species can grow more or less intensely or whether in that area a certain amount of yield can be produced of certain quality.

Apple, called the "queen of fruits" is the fruit species with fruits ripening from early summer until winter. It is known that there are more than 10,000 varieties of apples in the world. It can be said that the apple fruit is the most complete fruit in the human diet. To maintain a healthy body person should consume annually about 30 to 40 pounds of fresh apples (Krpina, I. and sur., 2004).Fresh fruit apples can be eaten throughout the year. Besides that apple fruits are used to make juices, compotes, jams, marmalade, dried apples.

According to the ripening time there is differentiation between summer, autumn and winter varieties of apples. In Mediterranean areas it is advisable to grow summer apple varieties (Brzica, K., 1991).Apple corresponds well to a moderate continental climate. For all of physiological processes, apples are suited with the temperature of about 20 ° C. The total annual rainfall needed for growing apples ranges from 600 to 1060 mm. If during the growing season temperatures are greater, the greater is the transpiration - so the need for water is present. In general it can be said that for apple growing favourable conditions are places where from May to September there is 600 mm of rainfall. Mild winds can be useful, and dry and cold winds are harmful, especially in time of flowering and pollination. Apples suit hilly terrains, hills and mountain slopes protected from the wind.

Apple seeks well-drained sandy loam, loam or clay loam soil, neutral to slightly acid reaction, rich in humus and nutrients (Miljkovic, I., 1991). Compacted clay soils are not suitable for apples, especially if a profile has shallow distributed, compacted and impermeable horizons. Because of stagnant rainwater in the soil and bad water-air relationship root suffocation occurs in apples**.**

Today's modern fruit production involves growing apples in the thick set. In order to achieve a dense set it is essential to choose the proper, i.e.low to moderately vigorous base. Selection of cultivation tree forms are conditioned by the properties (vigour) substrate, variety, soil properties, climatic conditions of the regions, the characteristics of the terrain, the maintenance of the soil, the application of mechanization. The most common forms of apple cultivation on low vigor base are: all forms of palmettes, slender spindle, spindle bush, cordons.

Figure 1: Thehigh-densityapple orchards, cultivationformspindlebush(Source: Saravanja, P.)

Pear is valued, highly profitable fruit species that gives copious yields of quality fruit. Thanks to the large number of varieties of pears from early summer to late winter, as well as good packaging of fruits, the season of consumption of fresh pearfruits is extended. In addition to usage of fresh fruit, pears are commonly used for: compote, juice, jam, brandy (Viljamovka).

According to the time of ripening, pear varieties are divided into: summer, autumn and winter. Summer pear varieties should be grown in warm southern areas, because they ripen earlier. Otherwise the pear is more demanding in terms of environmental conditions compared with the apple. It blooms before the apple, and the danger of spring frost is much higher. Pear does not tolerate extreme cold. Low temperatures have impact on flowers and young fruits. To avoid damage from freezing temperatures, pears should be planted on inclined surfaces at which the cold air does not stay, as a heavier air falls in the valley. Pear does not withstand high temperatures and low relative humidity. The total annual rainfall for growing pears is 600-1000 mm, with a condition to have even distribution of precipitation during the growing season. Otherwise pear requires the most water during intensive stages of growth and fruit saplings, i.e. in June and July when fruit setting of flower buds for the next crop year occurs. Soaking, just before the onset of high temperatures, which usually occur in the third decade of July and the first decade of August, can prevent or forestall leaf scorching and damage from it.

Pear requires deeper, well drained and lighter textured sandy-loam or loam and sandy loam soils neutral to slightly acid reaction. Pear does not tolerate alkaline and heavy clay soils. For the intensive cultivation of pears are used vegetative base of quince. From growing forms of pear on low vigor base are applied: spindle bush, spindle, palmettes and cordons.

Figure 2:Densecultivation of pears, cultivation formcordons (Source: Krpina, I. and assoc., 2004)

Peach

For peach it is said that vineyard locations suit it. With varieties of peaches, there is a difference between genuine peach and peach variety (nectarine).Also differentiation by the color of the meat establishes varieties of yellow and white meat. According to the purpose of the fruits it can be: varieties for table consumption and those for industrial processing. Adaptation of varieties of peaches to sum inactive temperature is different, so we have a variety for the Mediterranean area, the variety for the continental area, as well as varieties that can be for both cultivating areas.

The main limiting factor in growing peaches is the absolute minimum temperature. If there is a gradual cooling, peaches can beable to withstand the cold, compared in the case of sudden cooling. Also, damage may be greater if same absolute minimum lasts longer than the short-term phenomenon. Spring frosts are particularly dangerous in the cultivation of peaches. Peaches thrive in areas where the annual rainfall is at least 600 mm. In warmer southern areas where there are higher temperatures, where evapotranspiration is greater, the need for greater rainfall is present, especially if there is uneven distribution of precipitation. Water is needed during the late spring and summer, because of intensively growing shoots and fruits, and it is a period of differentiation of flower buds for next year.

Peaches require a sandy-loam or loamy-sandy soil where roots network spreads evenly. Not suitable are heavier textured clay loam or clay soils containing more than 25% of colloidal particles, or soil with a high content of active lime (Miljkovic, I., 1991).

Peaches can be grown in a variety of growing forms, but most commonly in the form of vases, palmettes and spindle bush.

Figure 3: Cultivation of nectarines, free palmettes (Source: Saravanja, P.)

Fresh fruits of apricots are a favourite fruit, rich in easily digestible sugars, organic acids, vitamins, minerals and flavour. For the cultivation of apricots,attention should be on the selection of soil and climate. Apricot is very sensitive to sudden changes in temperature in late winter and early spring, meaning it is sensitive to temperature fluctuations. Therefore apricots should be grown in areas where the temperature variations are less present: in the Mediterranean areas, near major rivers, or at selected locations, sheltered from cold, northerly winds. Apricot is a fruit species that ends very early deep or physiological winter hibernation. It needs a very small sum of active temperatures causing apricot blooms earlier than all fruit species, except for some varieties of almonds. This is the reason that the apricot blossoms frost due to occurrence of late spring frosts. Otherwise, apricot very well withstands high temperatures during the summer months. High temperatures and low humidity do not have a greater adverse impact on the growth and development of apricot, if the soil is maintained with adequate moisture, especially during the differentiation of flower buds (July, August), (Krpina, I. et al., 2004). Excessive moisture in the soil is affecting the growth and development of apricots, especially if apricots are cultivars on the base of wild almond or peach.

Apricot does not tolerate highly alkaline or highly acidic soil. The most suitable are deeper, sandy-loam or loam sandy, neutral and slightly alkaline soil. Depending on the base, it can handle the slightly heavier soils.

Apricots can be grown in the form of vases, spindle bush, palmettes.

The fruits of **sweet cherries** are among the earliest table fruit. Growing sweet cherries has a special meaning in the Mediterranean area, where they ripen about a month earlier than in the continental area. Sweet cherry tolerates welllow temperatures in period of deep dormancy, of course, if the trees are of good condition. It is a kind of fruit that quickly goes through a period of deep dormancy, which causes the movement in its early vegetation, increasing the risk of frost in the spring.

The cherry not tolerate high humidity but tolerates high temperatures well. (Krpina, I. et al., 2004). Increased relative humidity promotes the occurrence of plant diseases, and large amounts of rainfall during flowering interfere with pollination and fertilization, while during ripening cause fruit cracking and their faster decay. The most favourable total annual rainfall for growing sweetcherries is 800-1100 mm, with some literature sources indicate that the sweet cherry can grow with 500 mm annual rainfall, if distributed uniformly throughout the growing season. Sweet cherry is satisfied with a small amount of moisture in the soil, because its roots have a high adsorption power. Adverse effects on sweet cherry growth arestrong and dry winds, especially during flowering.

The best soils for sweet cherry are the deep, loose, favourablewater-air relationship, biologically active, neutral to slightly acidic soil.

Cherry naturally forms storey pyramid, so this growing method is suitable when the cherries grown on the lush bases. In addition to the tier of the pyramid, cherry can be grown in the form of a repaired pyramid, palmettes and with sloping branches. On the moderate lush bases sweet cherry can be formed in the spindle bush, Spanish vase, and on thelow vigor, the spindle, cordon, Tatura Trelis.

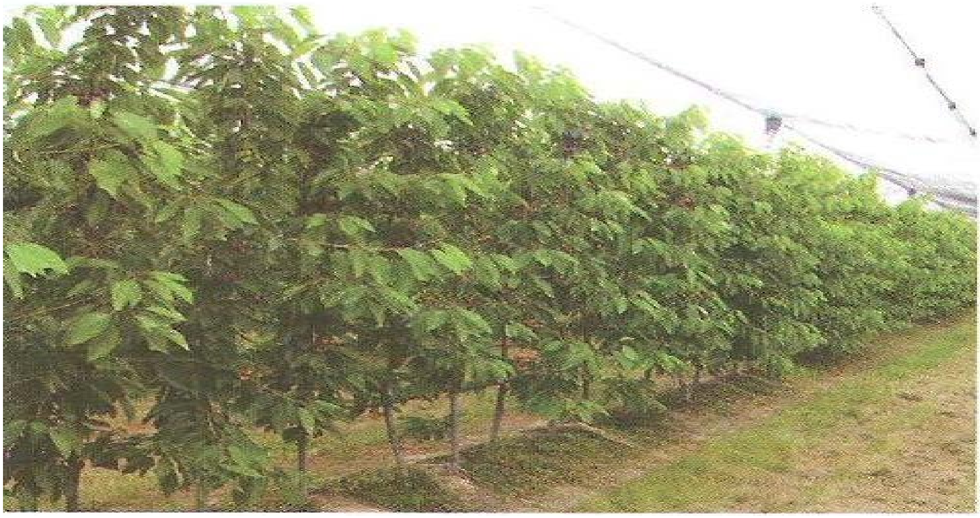


Figure 4: Cherries cultivation in the form of a column (kolonare) (Source: Miljkovic, I., 2011)

Cherry is a fruit which for the qualitative properties of the fruit is of great importance in the processing industry. Cherry can be grown in colder climates, but also in warmer, Mediterranean areas. Generally, one can say that cherry thrive well where apple and sweet cherry can be cultivated (Miljkovic, I., 1991).

At the beginning of the growing season cherry is particularly sensitive to low temperatures, with low night temperatures frosting of the trunk occurs (due to a surge in the morning warm-up of bark) in the form of cracking bark. Due to the low temperatures at flowering stage of development, the cherry blossoms can be damaged. It is resistant to high temperatures, so it would not suffer when the temperature exceeds 30 ° C. The lower limit for growing cherries is 650 mm of rainfall per year. Where there is insufficient rainfall during the growing season irrigation should be provided, particularly in southern areas.

Cherry gives the best of fruits at light permeable soils in semiarid climate. On heavier soils cherry suffers of root suffocation (asphyxia).

The most common cherry cultivating forms is repaired pyramid and vases, but can be grown in the form of a spindle bush, spindle.

Figure 5: Orchard of cherry Maraska, cultivation form vase (Source: Saravanja, P.)

Plumis one of the dominant fruit species in areas with higher altitude, or areas with features of moderate continental to continental climate. There are two major groups of varieties of plums: European plums and plums of the Japanese-Chinese origin. The varieties of plums of Japanese-Chinese origin bloom earlier and are more sensitive to cold, so it can only be grown in the Mediterranean area (Jemric, T., 2007).

The fruits of plums are used for consumption in the fresh state, drying, making juices, jams, compotes and making of plum brandy. Plum relatively better tolerates lower temperatures, so it rarely comes to frost. Sensitivity to low temperature depends on the position of the orchard, health status and age of the tree, on the properties of the varieties of plum and base as well as the current stage of development of vegetative and generative organs of plums. As with other fruit species, newly formedplums fruits are more sensitive to low temperatures. The quality of plum depends on average air temperature during June, July and August. If the average air temperatures during the mentioned months are between 18 ° and 20 ° C, it is ideal for good quality plums fruits. Plum requires areas where annual rainfall is 700-1000 mm, of which the vegetation period 400 to 500 mm (Miljkovic, I., 1991).

Plums grow well on deeper, well drained lighter soils, loamy sand soils, sandy loam and loam. However it tolerates well heavy loam-clayey and clayey soils which of course depend on variety and base. Suitable cultivation form for plum is pyramid shape or repaired pyramid, repaired vase. Cultivation form spindle bush requires less abundant base.

With figs, olives and vines, **almonds** are most abundant fruit species in southern areas. Fruits of almonds have high energy and nutritional value, which is widely used in food, pharmaceutical and cosmetic industries. The varieties of almonds by environmental growing conditions are divided into varieties of continental area and the variety of the Mediterranean area. Also based on the hardness of the shell are divided into varieties: hard, semi-hard, semi-soft, soft shell. When selecting the assortment of almonds, one should take into account the kernel percentage.

In terms of absolute minimum temperature, in the period of deep dormancy almonds behave like peaches. Early blossom varieties of almonds can be influenced by the frost due to spring frosts. However, almond well tolerates higher temperatures, and even up to 50 ° C, which is explained by anatomical and morphological characteristics and structure of its roots. Almond is quite resistant to burns, damages of leaves, shoots and fruits (Miljkovic, I., 1991). This kind of fruit can be grown in areas where the annual rainfall is only 500 mm, with rainfall evenly distributed in greater quantity in the first part of the growing season.

Suitable soil for growing almonds are deep, drained, sandy-loam or loamy soil, neutral to slightly acidic or slightly alkaline reaction. Does not tolerate heavy clay and marsh, and more calcareous soils.

The most commonly cultivation form is of ordinary and repaired pyramids and vases.

The **walnut** is one of the most adoptable fruit species because it thrives in coastal and inland areas. During the period of deep dormancy,walnut can tolerate quite low temperatures. Walnuts suffer from cold during spring due to spring frost. With a temperature higher than 38 ° C and with humidity below 60% there is leaf blight.

Walnut requires a large amount of rainfall, and is especially sensitive to lack of water in the spring shortly after fertilization. In the event that during the stage of development of growth and development of the fruit there is less rainfall, there will be a stronger decline in fruit and fruit will certainly remain smaller and poorer quality. Warm, dry wind is especially harmful during the intensive growth of shoots, because it causes excessive evaporation from the soil and transpiration through the leaves, leading to injuries and drying the leaves of the walnut which is in this respect much more sensitive than other fruit trees.

Basins and valleys of depression are rarely suitable for growing walnuts, because they represent a lake of cold air. Slightly tilt positions, Plateau, southern exposure, with moderate convection are the most favourable for the cultivation of walnuts. Walnut requires alluvial or dealluvial soil, rich in humus and biogenic elements, a pH of 5 to 8. Walnutsare not suitable in heavy clay soils, which occasionally contain excess of water.

For the cultivation of walnuts it is important to select suitable positions, later flowering varieties with particular attention to the length of the vegetation of certain varieties.

Walnut is usually grown as a vase or repaired pyramid. Tree height should not exceed 100-150 cm, because the higher tree trunk with delay fruit production, except if it does not relate to the cultivation of walnut for wood industry.

Fig is a typical subtropical fruit species with fruits that have high nutritional value and nutrition therapeutic values. Figs fruits are used fresh, dried and processed for a variety of jams and sweets. According to the time of ripening, figs are divided into single breed and double breed. Based on the skin color of the fruit, figs are divided into: black and white.

The fig tree has specific requirements according to climatic conditions and particularly to the lower temperatures. Resistant varieties of figs to lower temperatures is conditioned by hereditary characteristics of the variety, state of health, tree, tree age, fertility in previous vegetation. The spring frosts has more impact on varieties with vigorous growth of vegetation which starting earlier with vegetation, i.e., first to have leaves. Fig well tolerates high temperatures. For the cultivation of figs there is requirement of 800 mm of rainfall per year. It is essential that during the stage of development in fruit ripening, figs have enough heat and moisture in the soil.

The fig grows best on deep, well-drained lighter soils. Otherwise fig very deep stretches roots network, it certainly helps it to overcome drought well. Alluvial soils suit fig, dolomite erosions, brownised red, undeveloped calcareous soils. The fig tree is not susceptible to chlorosis. For the cultivation of figs heavy and marsh areas are not suitable.

Figs are grown in the shape of a repaired vase; pyramid with lower or upper trunk or in the form of a bush.

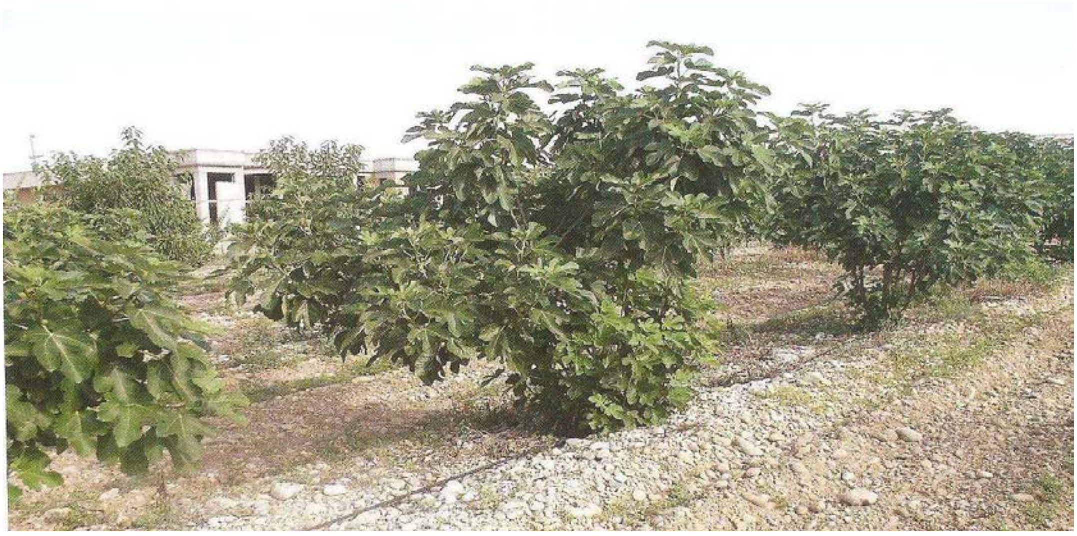


Figure 6: Figs orchard with irrigation system (Source: Vego, D. and assoc., 2008)

Pomegranates grow very well in the Mediterranean area. It is excellent atwithstanding high temperatures during the summer months, but is very sensitive to low temperatures. All varieties of pomegranate are not equally sensitive to the cold. Varieties of acid and moderate acid pomegranates are more resistant to cold (Miljkovic, I., 1991). Different species of pomegranate are specific for different countries, which mean that environmental conditions are specific for cultivation areas.

Early autumn frosts are very dangerous for pomegranate, positions where they often occur should be avoid. Pomegranate requires a sufficient amount of rainfall during the intensive growth of the roots in the fall and spring as well as during growth of shoots and fruit.

It thrives best in deeper, well-drained, loose, sandy-loamy soils that have good relations of water-air and contain plenty of organic matter. Soil should be neutral to slightly acidic reaction. It does not go well with heavy clay and very moist soil.

Pomegranate naturally forms a shrub, and the cultivation of the most commonly encountered in the form of a bush, but it can be grown in the form of a shrub vase, with a low trunk, with four to five regularly spaced basic branches.

Figure 7: Pomegranate in the form of low stem (Source: Saravanja, P.)

Olive is part of the rich plant community of the Mediterranean, the noble fruit species. Many consider it to be healing fruit because of its healthy and nutritious oil. Consumption of olive oil and table olives is increasing in recent years.

Area of olive cultivation is limited to its specific requirements according to climatic conditions. Low air temperatures are one of the climatic factors which limit its distribution area of cultivation. Olive blooms later, thus avoiding spring frosts. High temperatures are well tolerated, of course if the tree is well supplied with water. It is believed that the olive tree is very resistant to drought. However, this is only true in the case of extensive farming. Total annual precipitation sum required for the cultivation of olives is 300-800 mm. Olive fruit grows extensively in August and September, and during this period it is necessary to provide water, especially for table varieties. Olive favourssouth-western positions, gently sloping, well-lighted and airy. Positions exposed to strong winds, south and strong winds should be avoided or protect with windshields.

Olive requires drained soil, sandy-loam and loamy-sand, deep, stocked with humus and mineral nutrients. It is also good that the soil contains a lot of calcium that is neutral to slightly acidic or slightly alkaline pH reaction. Dense, marsh, bad water to air relations soils are not suitable heavy.

Among the many forms of cultivation for the olives the best forms are different types of vases: polyconic vase, cylindrical-conical or cylindrical vase, because olive requires a lot of light.

Figure 8: Olive plantations, cultivation form vase (Source: Saravanja, P.)

Blackberry is very interesting for cultivation for several reasons: early fruit bearing nature, already in the second year, brings fruits abundantly and regularly, fruits are rich in nutrients, harvest begins in late July when are no major agricultural operations, and there areexport opportunities, processing into juices, jams, compotes, blackberry wine.

In deep winter dormant state blackberry may tolerate up to -20 ° C. It blooms late (mid-May to mid-June), so it avoids spring frosts. It seeks a lot of light, so the shaded positions and narrow rows adversely affect the maturation of fruits. It grows well on lean, hilly locations, where there is a moderate airflow. It is mostly southerly locations for quick draining of rainwater. It tolerates drought better than raspberries, because the root are deeper rooted. If there is not enough moisture in the summer months, the yield will be reduced and there will be insufficient shoots to grow the next crop year.

Blackberry prefers soil rich in humus and biologically active soil, slightly acid to neutral soil. It is not suitable for soil with bad water to air relationships, dense and heavy soils, rocky, more acidic soil, or more calcareous soils. Blackberry is grown as a bush in square planting a bush in a rectangular planting, in the lines, in the system of hedges.

Raspberry fruit species is suitable for family farms. It is grown for fresh fruit sale, or more frequently for processing and freezing, which refines the product and raises its price. Raspberry seeks fresh climate, with moderately hot summers and sufficient rainfall. Raspberry has shallow root spread, and is sensitive to low winter temperatures, when there is no snow cover. Raspberry blooms in late May and avoids the spring frosts. The locations for growing raspberries should be well lighted. Rainfall is very important for successful cultivation of raspberries, which should be greater than 800 mm per year (Miljkovic, I., 1991). In the growing period there should be at least 400 mm of rainfall. In dry conditions, shallow developed roots of raspberries are suffering, in addition to that on the clay texture soil damages occurs on the roots of raspberries.

Raspberry favours slightly inclined and sunny positions, with stream of air. Because of the cold air in the spring or stagnation of moisture during growth and ripening of the fruit,it suffers from disease. Strong winds can damage the fragile shoots of raspberry.

Loose, humus-rich, slightly acidic soils are very well suited for raspberries growing, which are good with water distribution. Compacted clay soil, as well as carbonate and alkaline soils are not suitable for growing of raspberries.

Raspberries can be grown in the form of square planting shrubs, bushes in the rectangular planting, in the lines, in the system of hedges.

Figure 9: Raspberries plantationwithPVCcover (Source: Saravanja, P.)

Strawberry is a fruit species of wide geographic distribution, which occupies a central place in the group of berries. This is the first fruit early in the year, attractive, used fresh, canned or frozen. This fruit species in the cultivation is the fastest to returns the investment and allows for good profits on relatively small areas (Krpina, I. and assoc., 2004). It is well adapted to a variety of soil types and climatic factors, it can be grown at different altitudes, thus extending the period of harvest and more consistent markets supply. Strawberry easily and rapidly propagated in relation to other types of fruit and produces fruit in the year immediately after planting.

As far as the temperature during dormancy under snow cover, strawberries may tolerate very low temperatures, without snow cover it can tolerate up to -15 ° C. Low temperatures can result in negative consequences for the strawberries that were planted late and insufficiently rooted. High temperatures during flowering and during fruit formation and ripening lead to the loss of water from plants and soil, resulting fruits are smaller, poorer in quality. The adverse effect of high temperature has more impact on the clay or lighter sandy soils, because in these soils moisture is lost much faster. Strawberry is very sensitive to temperature fluctuations especially during flowering, when they can be the cause of the formation of deformed fruits. With strawberries, attentionshould be paid when choosing varieties, because some varieties are adapted to the longer duration of dormancy and have higher requirements to the sum of inactive temperature. Such varieties cannot be grown in warm southern areas.

Strawberry best suits to open, flat or slightly inclined south, southeast or southwest positions. Closed valleys, where during the cold and clear nights cold air is accumulated, and very windy, and the positions of the large slope are not favourable for growing of strawberries.

Strawberry prefers lighter textured sandy-loam soils, loose, airy, rich in humus and nutrients. Unsuitable soils are heavier clay and sand, as well as alkaline soil. The most favourable pH of the soil reaction is slightly acid to neutral.

For successful production of strawberries it is recommended to take a healthy planting material, which is under the supervision of authorized institutions. Strawberry can be grown outdoors and indoors (greenhouses, tunnels) space. It can be planted in rows, the lines, rows, with or without foil.


Figure 10: Production ofstrawberriesin the greenhouse Figure 11: Production ofstrawberriesonfoil
(Source: Krpina, I. and assoc., 2004)

2.3.2. Vegetables (cabbage, tomatoes, peppers, watermelon, cantaloupe, cucumber, lettuce, onion, carrots, beans, potatoes)

Cabbagesare a vegetable of high nutritional value, which is usually consumed fresh, while during the winter consumption of pickled cabbage increases. The biggest role for a period of growing has the microclimate of cultivation areas. In the southern regions with mild winterscultivation of early and winter cabbage for fresh consumption is set. Using modern technological processes, cabbagecan be harvested all year round. Late cabbage is cultivated in the highlands and northern areas, very often without irrigation, which reduces yields. From this production, except for consumption in the fresh state, some varieties are used for pickling.

According to the Agency for Statistics of Bosnia and Herzegovina in 2012, cabbage and kale are sown on 5,604 hectares. With harvested area (5545 ha) a total of 62,079 tons have been produced, which is 14.2% less than in the same period of 2011. The actual yield of 11.2 t / ha is quite low compared to the yields in agriculturally advanced countries. In some areas, because of good adaptation to environmental conditions, some local ecotypes of cabbage are often represented in the production. Local ecotypes have high quality, but yields were significantly lower in comparison to a selected cultivar. In producing the largest share is in very early hybrids that achieve the highest market price.

Although cabbage has high water requirements at all stages of growth, the plants are most sensitive to lack of water after transplanting and initially forming of heads. In the area of Herzegovina in these stages it is necessary to provide irrigation in the period January-October. After transplanting cabbage claim 380 mm to 500 mm of water depending on climatic conditions (Madjar and Sostaric, 2009). The most common method is irrigated drop by drop, or sprinkling, which increases the humidity, which is beneficial to the growth of cabbage. After a dry period even in irrigated plantation, cabbage,because of sudden changes in the water regime of the soil, leads to head cracking, significantly reducing the quality of cabbage.

Figure 12: Irrigation of cabbage *Figure 13: Cabbage irrigationby sprinklingmethod, drop by drop*
(Source: Sefo, E.)

Tomato is one of the five most cultivated species in our vegetable production. Due to high health and nutritional value it is unavoidable in the daily diet. In B&H tomatoes are produced on 3,749 ha, but production capacities are much higher. The average yield of 11.9 t / ha, which is the 2012 statistics data is quite low, influenced by significantly lower rainfall and high temperatures during the growing period.

In the area of Herzegovina tomatoes are grown mainly for consumption in the fresh state due to lack of processing capacity. Growing tomatoes in open areas is possible from mid-April until mid-October. Because of great summer heat in the cultivation early varieties are preferred, while in areas where there is no occurrence of frost in mid-May late mid-late varieties are cultivated.

Production of tomatoes in greenhouses occupies an important place both in structure and in terms of volume of production. Although in protected areas production can be organizedthroughout the year, the tomato in Herzegovina is primarily grown as an early spring and early autumn culture achieving high market prices. To reduce the risk due to soil salinity in southern Herzegovina,different bio stimulators are applied increasingly making the plant better resistant to the stress conditions. Tomato plants have the greatest need for water at the stage of receiving a transplant, flowering and fruit creation. As a result of water stress blossom-end rot often occurs. Irrigation is done in shifts, usually using drop by drop.

Figure 14: Tomato on black foil, underirrigation drop by drop

Figure 15: Preparation for planting with foil

(Source: Sefo, E.)

Paprika is an extremely prized vegetablewith high economic value. Mostly used fresh, but it is also an important raw material for processing. According to statistics for 2012 B&H produced a total of 35,384 t of paprika with an average yields of 10 t / ha. Yields are low, primarily because of the lack of knowledge of the biological properties and applications of inadequate agro-technical systems.

Paprika is produced from seedlings which makes it the biggest item in production cost. Direct seeding of paprika in our terms and conditions is not applicable because of the long period of emergence and lack of water. Production of paprika is organized in open areas and in different types of protected area where it is one of the most abundant crops.

Because of shallow developed roots and increased transpiration paprika is a huge consumer of water. Applying mulch of black polyethylene film better keeps the accumulated soil moisture, but these amounts of water are still insufficient for normal development. In the production of paprika from the time of transplantation irrigation is required. In the full productivity, in July and August, paprikafavours large amount of heat, but it also requires the greatest amount of water. It is necessary to maintain regime of moisture in the soil at the level of 70-80% PVK. Paprika is irrigated through the furrows between the rows, sprinkling methods, misty farming on soil covered with foil. It is estimated that in the irrigated crop of paprika yields are greater for 50%.

Figure 16:Irrigation of paprikadrop by drop (Source: Sefo, E.)

Watermelon is a typical thermophile plant. In conditions of dry and hot climate areas of southern Herzegovina watermelon fruits achieve significant production of quality. In recent years, the increased cultivation of watermelon seedlings compared to previously represents the most direct way of cultivating sowing into homes.

The application of modern production technologies, primarily using high-quality seedlings and soil cover and crop foils of various synthetic materials, it is possible to set earlier production, increase yields and expand the areal of cultivation of watermelon in less favoured areas. In particular, progress in the production of watermelon transplants is accomplished by grafting on resistant species of related pumpkins. Hybrids are represented in production, which are, compared to varieties more productive and more resistant to stress conditions, diseases and pests.

Watermelon has a very lush foliage and strongly developed root, which affects the large demands on soil moisture. It is important that the soil in the initial stages of watermelon development are supplied with sufficient quantities of water so the roots are developed in order to better absorb water from deeper layers. The optimum soil moisture is within the limits of 70-80% PVK. The greatest demands on soil moisture watermelon have in time of flowering and fruit ripening. Watermelon is usually irrigated with the drop by drop method. This method can be used frombeginning of fruiting every day, but 15-20 days prior to harvesting irrigation is interrupted because it is considered that fruits will be sweeter (Paradzikovic, 2009).

Figure 17:Watermelonon black foil,

Figure18: Graft seedlings, under is the irrigation system drop by drop

(Source: Sefo, E.)

Cantaloupes as watermelon are culture of sunny climates. It is grown because it is an aromatic and refreshing fruit. Herzegovina is a traditional cultivating area for cantaloupes. The quality of the fruit is in direct relation to high temperatures, high light intensity and low relative air humidity. In recent years, great progress was achieved in the production of melons, which led to increasein yields. Cantaloupes have high demands on soil moisture because of large evaporative surface of vegetative parts. Root has a great absorbent power, and it can draw water from deeper soil layers and thus it is easier to overcome the deficit of moisture in the dry season. The highest demands for water are in the phase of intensive growth of stems. Thanks to modern technologies of cultivation, cantaloupes are starting to be produced in less favoured areas, in open areas and in enclosed spaces. In order to produce earlier, farmers grow cantaloupes from the seedlings. In this way, there is a better utilization of production areas. Because of prevailingdrought in summer cantaloupes must be irrigated. As with watermelon,the most common method of irrigation is drop by drop with pipes that are placed on the bare ground or under black polyethylene foil.

Figure 19: Growing melons on black foil (Source: Sefo, E.)

Cucumber is one of the most widely cultivated vegetable crops. Due to the lack of processing capacity in Herzegovina there is no common production of canned cucumbers (gherkins), but prevalent production is of cucumber for consumption in the fresh state. Although it has increasing demands for temperatures, for speedy technological maturation it can be grown in areas with shorter summer period. Cucumber can be produced as early spring as well as early autumn crops. According to statistics, in B&H in 2012 cucumber yields stood at 8.1 t / ha, when the total production compared to the previous year decreased by 12.7%.

Excessive dryness of the air accompanied by high temperatures, which is a common occurrence in Herzegovina, has a very unfavourable effect on plant development. Cucumber cultivation in open areas irrigation can only partially increase resistance to drought. Due to high demands on soil moisture (85-90%) and humidity (90-95%) production is usually carried out in a protected area. Large cucumber water requirements are tied to large surface transpiration of stem and short growing season in which it has to form a large number of fruits with high water content of up to 95% of the total weight.

For the production of the protected areas, the safest choice is of hybrid cultivars purely female seedless (hybrid) in which each flower develops from the fruit without fertilization. Best results are achieved by transplanting seedlings in the ground that is covered with black polyethylene foil.

Cucumber cultivation in drought conditions leads to a decrease of flowers and newly formed fruit, to accelerated ripening of fruits which are shorter and deformed, and often get a bitter taste. In the initial stages of growth irrigation is less present, and with the first fruits more frequent and abundant irrigation has to be set. In cultivation in open areas,irrigation can be done in furrows, sprinkling or drop by drop, while in protected areas common method of irrigation is drop by drop, with occasional sprinkling to regulate humidity.

Figure 20: Growing cucumbers in protected space (Source: Sefo, E.)

Salad(lettuce) arevegetables with short vegetation that are grown exclusively for consumption in the fresh state. Due to moderate demands on heat, salad is better suited for chilly and not too humid areas in relation to the hot areas. In our conditions early spring and late autumn cultivation of salad can be organized in open areas. For summer cultivation higher mountain areas with mandatory irrigation are more appropriate. Depending on the terms of planting soil and crop cover is set withvariety of foils in order to create favourable conditions for growth. In the summer the ground is covered with white foils that reflect solar radiation and thus reduces the temperature. In the autumn-winter period, in protected areas two to three rounds of lettuce can be produced, and is usually grown in combination with other vegetables.

Our market preferred varieties of lettuce with bright green leaves. For lettuce cultivation it is important to properly choose the variety due to differences in sensitivity to day length and light intensity. In protected areas, as well as in open areas in the spring and autumn period the most cultivated type is maslenka, while for summer cultivation in open areas cultivation of lettuce type kristaka which better withstand high temperatures and are resistant to the early formation of the flower stalk.

The best yields are achieved with irrigation method drop by drop with simultaneous feeding with water-soluble fertilizers. The greatest need for water lettuce crop has in the initial stages of growth as well as the stages of forming and technological maturity of the head when it is best to irrigate at night and early morning. Irrigation maintains field water capacity of the soil within the limits of 60-70%. Thanks to modern technological methods it is possible to achieve yields of lettuce up to 30 t / ha.

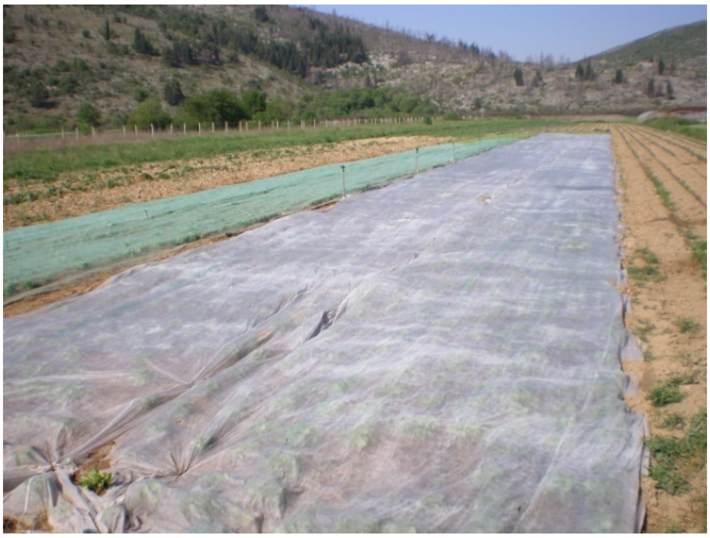



Figure 21: Salad onblack foil,

Figure22: Covering the salad with white synthetic material with irrigation system drop by drop

(Source: Sefo, E.)

Onions (red, black) have a wide areaof distribution. Herzegovina is a known cultivation area for the onions. The most widespread method of planting onions is with onion set (onionset-arpadzika), although it can be produced with planting seedlings as well as sowing the seeds for which it is necessary to provide irrigation.

At the beginning of the vegetation, onion responds well to lower temperatures and increased soil moisture, while at the second part of the vegetation dry and warm weather is more suitable. For this reason it is necessary to plant onion sets early in the spring to developroots and leaves before the dry period that favours the technological maturation of bulbs. While onions produced from sets well tolerates drought, irrigation can increase yields by 25%. Likewise, for the mild winters in this area it is possible for autumn planting of onion sets. In unheated greenhouses it is grown as green onions, usually as the previous crop to heat demanding vegetables.

Timely planting of quality onion sets and appropriate selection of types according to the length of days for each production area, along with other cultural practices can achieve high yields and good quality onions.

The carrot is the most cultivated species of root vegetables. In recent years, popularization of carrots increased because of the high health and nutritional value. Herzegovinahas extensive production of carrots. Most commonly it is planted in smaller areas and on private plots, although there is a great opportunity for the commercial production of carrots on larger arable land.

Carrots have moderate demands on heat, so it is possible to sow in terms of the different environmental conditions in the wider area of Herzegovina, which provides continuous cultivation throughout the year. Inareas that are warmer during the summer, harvest carrots are sown in early spring, while the later planting is avoided because of high temperatures and drought. In the higher areas and colder areaslate spring sowing is present in May and June for the autumn harvest. The production has early and mid-early cultivars of carrot type Amsterdam and mid early and mid-late cultivars of Nantes type for summer cultivation. For the intensive production of carrots, special attention should be paid to the selection of land, proper tillage, timely sowing in local conditions, types of cultivars, seed quality and compulsory irrigation, which can produce yields of up to 30 - 50 t / ha.High daily temperatures above 30 ° C with high night temperatures adversely affect the roots whichare poorly developed and remain thin and woody.Critical periods for water are the initial phase of development of roots and beginning of tricking of roots.

Irrigation should maintain field water capacity of the soil within the limits of 70-80%.The consequences of excessive amounts of water during the irrigation are longitudinal cracking of roots and reduction in sugar content and carotene, which significantly impairs the quality of the roots. Approximately fifteen days prior to extraction,irrigation should be stopped in order to preserve the quality of the roots.

Beans are one of the most important crops cultivated in agricultural production. Although beans have higher requirements for heat because of short vegetation it can be grown in different climates. In the area of Herzegovina, there is greater production of dry beans compared to the green beans which is associated with processing capacities. Time of sowing depends on location or on the occurrence of late spring and early autumn frosts.

Dry beans, because of longer vegetation, are planted only in the spring, so that most of the vegetation is in warm and dry conditions with mandatory irrigation. Very often high dry beans aregrown together with corn. Low green beans haveshorter vegetation and extended areaof production. In warmer southern regions, low green beansare sown in spring or early fall for the autumn harvest, while in the higher areas, green beans are most successfullygrown in the summer. Highgreen beans are sown in spring because of unlimited growth with mandatory use of irrigation during the summer. In protected areas, high green beans varieties are cultivated which leads to greater economic effects in off-season production.

The critical period for water requirements is in the phase of blooming and development of green beans. In the conditions of high temperatures of 35°C and lack of moisture flowers and set green beans fall off which decreases the yield. Toachieve stable yield it is necessary to secure timely and regular irrigation. Average irrigation is done 3-5 times with 20-30 mm of water depending on time of production and climate. For beans the best irrigation is done witha sprinkler because of increased requirements for moisture in the air.

Figure23: Physiologicly mature beans *Figure24: Plant of high dry beans*

(Source: Sefo, E.)

Potatoes are considered a vegetable with priority importance in agricultural production. Bosnia and Herzegovina, in 2012, has produced a total of 299,935 t of potatoes, which is 27.3% less than in the previous year. The average yield was only 8.2 t / ha.Quality of agro technics, selection of varieties and quality of seeds are fundamental elements of a successful production of potatoes. The areaof Herzegovina is known for its production of early potatoes, where very early varieties achieved good economic results. High temperatures and drought adversely affect the formation of nodules, so the mountainous areas are most suitable for the cultivation of edible and seed potatoes.

Potatoes have modest requirements for humidity and temperature, and don'ttolerate large fluctuations during the growing period. For this reason, in arid areas it is necessary to irrigate crops, which affects the yield and quality of tubers. For good growth of potatoes there should be 400-800 mm of water, depending on weather conditions and the length of the growing season (Lesisand assoc., 2002). Plantation of potatoes can be irrigated though the furrows or sprinkling method. Using modern technological processes,it is possible to achieve significantly higher yields of 30 t / ha and a maximum of 50 t / ha.

Figure25: Potato cultivation (Source: Filipovic, A.)

2.3.3. Table grapes

According to data of the foreign trade chamber in 2011, B&H imported 10,277,297.22 l of wine and 4,334,946 kg of table grapes.During the same period in the same area 10.3 million litres of wine and 550 000 kg of table grapes have been produced. From this data it can be seen that the domestic market has the space for increasing of the production of wine grapes and wines, especially table grapes.

Options for product placements are much greater if we add market of countries, in the immediate and distant neighbourhood, whichdo not haveenvironmental conditions for growing grapes. The space on the market is anopportunity, but the profitability of production depends on a lot of other factors.

Figure26: Showcase vineyard, Bisce polje (Source: Lasic, V.)

Fragmentation of land for agricultural production negatively affects the profitability of production. Expensive funding for the cultivation of multi-year crops also negatively affect the profitability of production.

Expensive inputs for production, such as machinery and trailed implements, fuel, fertilizers, protection means, adversely affect profitability.

Cooling facilities for storage and packing facilities are expensive to build, especially if builtfor small land areas, and even more expensive to maintain, which also affects the profitability of production.

Investment in irrigation system, without which there is no safe production of table grapes, is costly to small areas and negatively affects profitability.

The share of human (manual) labour in the production process is very high, especially in the production of table grapes and has negative impact on profitability. A high proportion of human labour has another dimension as a social care (in part) to a large number of people.

The number of negative impacts islarge but their effect can be significantly mitigated, even annulled, with good agricultural policy measures - all except for the labour. Table grapes (early and late varieties) achieve high prices in the market. Despite the large number of negative impacts, the production of table grapes can be considered promising and profitable.

3. CLIMATE AND CLIMATE CHANGE

3. 1. Climate specificity

There are more than 50 definitions of the term climate. Climate, among other, represents a set of temporal processes which characterize the average physical state of the atmosphere over a smaller or larger area. Climate, in a narrow sense, is the average balance of weather in a given area and a given period, taking into account average and extreme deviations. This is the definition published by the Intergovernmental Panel on Climate Change (Intergovernmental Panel on Climate Change - IPCC). Climate, in a wider sense, is the general condition, including a statistical description, of the climate system. While the weather is changeable, climate, conditionallyspeaking,consists of unchanging characteristics of some geographical region. To determine the climate of an area, it is necessary, first to record weather data over a period of 25-30 years. After the measurements, average values of certain elements are calculated, according to which the type of climate of that specific area will be determine.

3.1.1. Climate specific of Bosnia and Herzegovina

Bosnia and Herzegovina has several conditions that have led to a wide range of climate types: general circulation of the atmosphere and the air mass whichare moving upwards, dynamic relief, directions of mountain ranges, its hydrographical network and proximity to the Adriatic Sea. The result is a moderate continental climate, which is represented mostly in the northern and central parts of the country, the sub-mountainous and mountainous (over 1000 m), the Adriatic (Mediterranean) and modified Adriatic climate type are represented in the seaside town of Neum, which also applies to the lowlands of Herzegovina.

General climatic characteristics of Bosnia and Herzegovina are influenced by the characteristics of the Adriatic Sea, local topography - particularly Dinarides Mountains, which are located along the coast and run from northwest to southeast parallel to the coast - and the atmospheric circulation at the macro level.

For the reasons mentioned above, the climate of Bosnia and Herzegovina varies from moderate continental climate in the northern part of the Pannonian lowlands along the Sava river in the foothill zone, to the Alpine climate in the mountainous regions, and the Mediterranean climate in the coastal and lowland areas of the Herzegovina region in the south and southeast.

In the lowlands and in the north part of the country, air temperature generally varies between the -1 and -2°C in January and between 18 and 20°C in July. On high grounds with the altitude if over 1000 m, average temperature varies from -4 to -7°C in January and 9 to 14°C in July. At the Adriatic coast and in the lowlands of Herzegovina region, air temperature varies from 3 to 9°C in January, from 22 to 25°C in July. Extreme temperature have been recorded -41, 8°C (lowest) and 42, 2°C (highest).

Lowlands of northern Bosnia and Herzegovina have annual temperatures ranging between 10°C and 12°C, in the areas above 400 m the temperature is below 10°C. The average annual air temperature in the coastal area is between Srednja12 and 17°C.

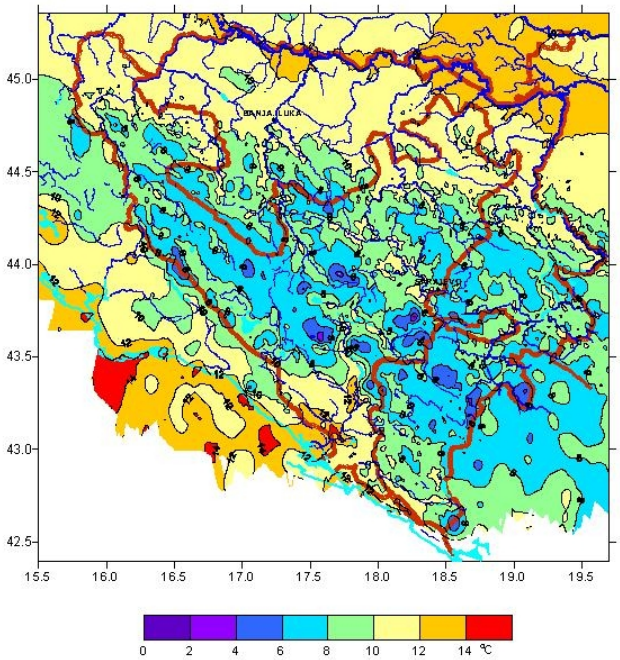


Figure27: Area distribution of average annual air temperature in B&H, 1961-1990(Source: INC)

Annual precipitation ranges from 800 mm in the north along the Sava river, up to 2000 mm in the central and southeastern mountainous regions of the state. In the continental part of Bosnia and Herzegovina, which belongs to the Danube River basin area, the main part of the annual rainfall occurs in the warmer half of the year, reaching a peak in June. The central and southern part of the country, with many hills and narrow coastal areas, is characterized by maritime pluviometric regime under the influence of the Mediterranean Sea, so that the maximum monthly precipitation is reached in late autumn and early winter, mostly in November and December.

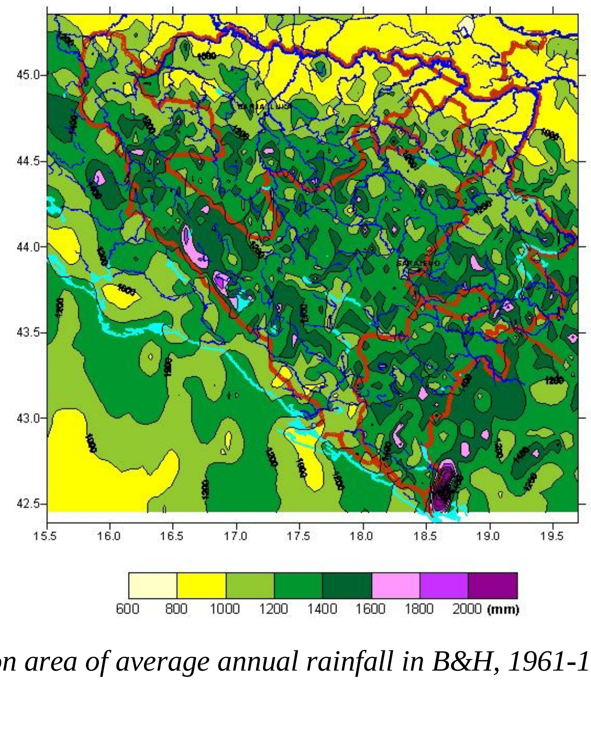


Figure 28: Distribution area of average annual rainfall in B&H, 1961-1990 (Source:INC)

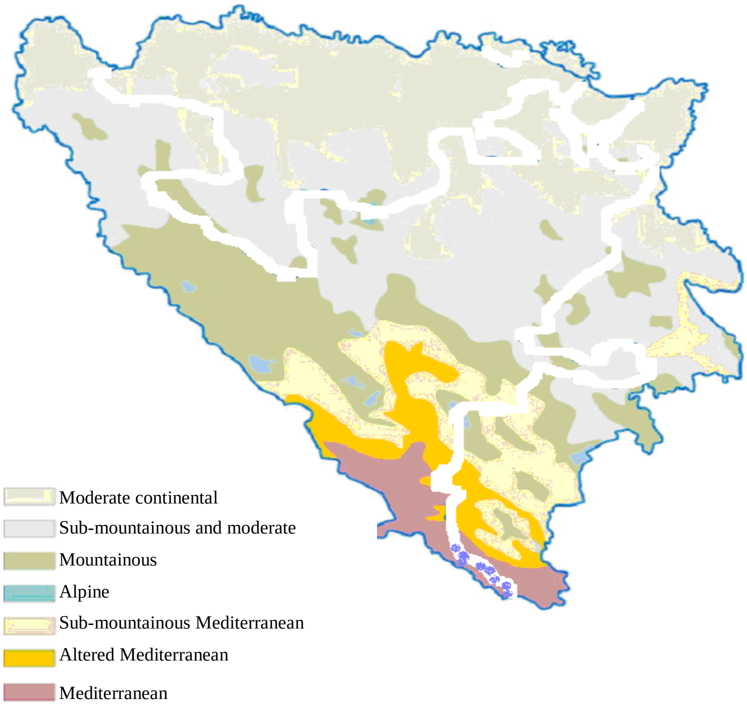


Figure29: Types of climate in Bosnia and Herzegovina (Source:INC)

The duration of sunshine periods are decreasing from the coast toward inland and at higher altitudes. The annual duration of sunshine in the central mountainous area is 1,700-1,900 hours, with the lowest insolation (1,700 hours per year) and the cloudiest (60-70%) conditions. Due to the frequent fogs during the cold period of the year, the solar irradiation in the interior is lower than at the same altitude at the seaside. In southern regions, there are 1900-2300 hours of sunshine (Mostar 2285 hours). In northern Bosnia and Herzegovina hours of sunshine are 1800-2000, more in the eastern region than in the western. Cloudiness decreases from west to east.

The average annual rainfall in B&H is around 1,250 mm, which, considering that the area of Bosnia and Herzegovina is 51,209 km^2, is 64 x 109 m^3 or 2,030 m^3/s. Drainage from the territory of Bosnia and Herzegovina is 1,155 m3 / s, or 57% of total precipitation. However, this amount of water is not evenly distributed, either spatially or over time. For example, the average annual outflow from the river Sava, with surface area of 38,719 km2 (75.7%) in Bosnia and Herzegovina is 722 m3 / s, or 62.5%, while the outflow from the Adriatic Sea, which has an area of 12,410 km2 (24.3%) in Bosnia and Herzegovina is 433 m3 / s, or 37.5%.

3.1.2. Climate specifics of Herzegovina

The Mediterranean climate is represented throughout the low-and high-Herzegovina. Therefore, one must distinguish between two types of Mediterranean climate. The area of low Herzegovina, corresponds to the lower Neretva with the surrounding karst fields lower than 1000 m above sea level: Ljubusko, Imotski-bekijsko, Mostar and Stolac. This type of climate in low

Herzegovina is based on the fact that its space is under the direct influence of the sea air. The Adriatic Sea during winter radiates into the surrounding space accumulated heat during the summer so the winter temperatures are significantly elevated. The average temperature in January in Mostar is 4.6 ° C, Stolac4.3 ° C, Ljubuski 4.7 ° C. During summer, the influence of the Adriatic Sea is negligible, due to limestone rock, which when heated are changing the temperature of the area. Summers are very hot and dry. Fluctuations in the temperature range from 20 ° to 21 ° C. Autumn is warmer than spring. Average absolute minimum temperatures range from -4.9 ° to -8.7 ° C, while the absolute minimum can drop to -17 ° C. In this area storms are dominant, with a change to south winds. The calmest month is October and February is the windiest. The rainiest month is October, with 200 mm of rainfall on average. There is almost no snow. Annual rainfall ranges from 1000 to 1500 mm.

The climate of Bosnia and Herzegovina is conditionedby basic climatic factors: geographical location, geological substrate, relief, coverage of the field crops and proximity to the Mediterranean. In addition to the basic factors,extreme factors occurthat significantly influence the overall climate picture of Bosnia and Herzegovina. In the first place, there are sub-tropical belt currents, high air pressure and a sub polar belt, and low air pressure, which results in the change of polar and tropical air masses. Then the polar air arrives with the currents from Atlantic, cyclones from the Mediterranean and the Adriatic Sea, and anticyclones coming from continental Asia. All these circulating-radiation processes are greatly disturbedby relief that acts as a modifier. These factors are causing the territory of Bosnia and Herzegovina to have two main climatic regions: north and south, which are separated with the line of Bihac-Sarajevo-Foca. The northern region has a continental climate character, with cold winters and hot summers. In the southern region there is aMediterranean climate with warm summers and wet winters. The line that separates the southern and northern region is the area of high mountains, plateaus, basins and cliffs where a typical mountain climate prevails. In this area, the winters are cold and summers are fresh with an increased intensity of rainfall that are evenly distributed throughout the year, while the temperature variation alternates with increasing altitude.

The modified Mediterranean climate covers the area of high-Herzegovina. In this higher Herzegovina and south-western mountainous area climate is approaching the mountainous, but with Mediterranean characteristics. Air temperature decreases with increasing altitude and distance from the sea. For every 10 km away from the sea, temperature decreases from 0.6 ° to 0.8 ° C. Winters are harsh with the absolute minimum temperatures of -14 ° to -25 °C. The average temperature in January ranges from -1.8 ° to -6 °C.On average, the absolute maximum temperature may rise up to 40 °C. As in low-Herzegovina, autumn is warmer than spring, but the temperature fluctuations are increased. Annually, this area has 1800 mm of rainfall. Strong winds are most present in the winter and are very strong at the folds. Cloudiness is increased compared to low-Herzegovina.

3.2. Climate and climate change in B&H

A team of experts from different areas of Bosnia and Herzegovina participated in the creation of the first national report on climate change for the country. This report has in the best way sublimated all the dangers, challenges, facing Bosnia and Herzegovina in the coming period related to climate change.

Using EH5OM global model, it is estimated that the temperature in B&H will increase from 0.7 to 1.6 °C by 1 °C global increase during the period 2031-2060. It is clear that the average rise in temperature (average daily mean temperature over a period of 30 years) is between 1 and 2 °C along the coast, and between 2 and 3 °C in the interior. The largest temperature increases will occur in summer and in inland areas:$T_{average}$ at 4 °C and T_{max} by 5 °C on average. Furthermore, it is expected that T_{max} will increase more than T_{min}.This leads to an increase in the number of summer days,defined as the number of days when T_{max} exceeds 25 °C from 2-6 weeks, or about one additional month of summer days on average. Finally, the increase in the number of hot days in the Balkans, is defined as the number of days with T_{max}> 30 °C, varies from two weeks along the coast up to 5-6 weeks inland.[3]

As for precipitation, using EH5OM global model, the summer climate will be noticeably drier in Southern Europe. This is especially noticeable during the summer (June - August), when even the small amounts of rainfall could be halved. In all parts of the Mediterranean (including the Balkans) rainfallis expected to see a reduction in the summer and a small increase or no change in other seasons during the period 2031-2060.On average, it is expected that the Mediterranean region will have more dry days. The increase in dry days is likely to be lower along the coast, but more in the interior of the Balkans.

Increasing variability in time was observed in all seasons, with rapid changes in short periods (five to ten days) of extremely cold or hot weather - heat and cold waves - and periods with extremely high levels of rainfall and drought. It is expected that the duration of dry periods, the incidence of torrential flooding and soil erosion will increase over the next century. In addition, the expected increase in the occurrence of hail, storm, thunder and the maximum wind speed may pose a threat to all forms of human activity.

3.3. Predicting climate change in B&H in the future

Scientific studies of global climate are based on measurement and modelling so there is no place for claims which are not substantiated with arguments and proven with multiple independent methods. In simulations of future climate models it is important to distinguish between forecasts and projections since it determines the interpretation of the results of climate models. Models of weather forecasting, knowing precisely what the current state of the atmosphere, predict weather for a few days in advance.

As a result of past and current emissions of greenhouse gases, impacts of climate change can also be observed in Bosnia and Herzegovina.B&H must be prepared to respond to climate change - and to maximize its opportunities whenever they arise - through a better understanding of its vulnerability, increasing resilience to climate change, as well as through capacity building. Initial National Communication (INC) and the Second National Communication (SNC) on Climate Change recognize the fact that climate change has an impact on Bosnia and Herzegovina, as well as the fact that these changes will occur rapidly until the end of the 21st century.Conducted studies on temperature changes during the period 1961-2010 indicate that the temperature has increased in all parts of the country. During the period 1981-2010, the largest increase in average temperatures in the summer months are recorded in Herzegovina (Mostar + 1.20 ° C) and central regions (in Sarajevo + 0.80 ° C), while the largest increase in temperature during spring and winter was recorded in the northern central areas (in Banja Luka + 0.70 ° C).The rate of temperature rise has increased during the last decade. Although this increase has been observed in ashort period of time, it is worrisome because it could indicate that the speed of climate change is increasing. In the period from 1981 to 2010, a large part of the territory of Bosnia and Herzegovina has experienceda trend of slight growth in annual precipitation in relation to the period from 1961 to 1990. The largest increase in the annual amount of rainfall was recorded in the central mountain areas (Bjelasnica and Sokolac) and near Doboj, while the largest deficit was recorded in the south (the area of Mostar and Trebinje). The largest decrease in the amount of rainfall was recorded during the spring and summer in the Herzegovina region (20%). During the fall the largest increase in precipitationwas recorded, especially in the northern and central areas. According to the INC report, thispoints to the fact that climate change in B&H is not as pronounced as in some other parts of the world. However, according to various sources,B&H has been classified in the

[3]*Initial national report on climate changes in B&H*

category of countries that are vulnerable to climate change, and this is evidenced by floods and droughts.

The increase in average annual air temperature in the territory of Bosnia and Herzegovina in the last 100 years is 0.6 ° C.In accordance with the climatological forecasting models, it is expected that the average seasonal temperature changes in the period 2001-2030 are in the range of +0.80 ° C to +1.00 ° C above the average temperature. It is anticipated that the winter will be warmer (0.50 ° C to 0.80 ° C), while the largest changes will occur during the summer months - the 6th, 7th and 8th month, with anticipated changes of +1.40 ° C in the northern regions and +1.10 ° C in southern areas.

It is estimated that the amount of rainfall will decrease by10% in the western areas of the country and that there will be an increase by5% in the east. It is expected that fall and winter will have the biggest decrease in the amount of rainfall.

Climatological forecasting models that have been applied to Bosnia and Herzegovina are forecasting further significant increase in temperature during the period 2031-2060, with a predicted increase in average temperatures ranging from 1 ° C to 2 ° C in the coastal areas, and ranging from 2 ° C to 3 ° C in the interior of the country.These temperatures, which are already at alarming levels and which will have negative impacts, also hide some other alarming changes. It is expected that the largest increase in temperature will occur in the inner parts of the country during the summer months: average summer temperature could be higher for 4 ° C, and the maximum summer temperature will be higher by 5 ° C. It is likely that the number of days during which the temperature exceeds 25 ° C will rise by two to six weeks a year. The number of 'hot' days, during which the temperature will be above 30 ° C, will increase by five to six weeks a year in the interior of the country. In addition to the rise in temperature, climatological forecasting models predict that in the period 2030-2060there will be significant changes in precipitation. It is expected that the Western Balkans will experience a reduction of the amount of summer rainfall, when the precipitation could be cut in half compared to current levels. The number of dry days in the interior will be increased.[4]

3.4. Greenhouse effect and its impact on climate change

The greenhouse effect has a very important role in warming of the Earth's surface. The concentration of greenhouse gases in the atmosphere is always changing. The combustion of fossil fuels, which man is using as the main power source, and the concentration of greenhouse gases over the last 200 years are changing rapidly;and as a consequence there exists climate change. Although climate change is now intensively studied, the consequences of these changes in the future cannot be viewed in its entirety.

The climate today is often studied as a system consisting of the atmosphere, hydrosphere, cryosphere, biosphere and geosphere.The system is very complex and is connected with many interactions between the various components.Although today there are many climate researches, there are many unknowns that must be investigated and proved. The main source of energy for all climate processes in the atmosphere is the Sun.

United Nations Intergovernmental Panel on Climate Change (IPCC), which publishes its views in annual reports, believes that anthropogenic (i.e. caused by human activities) gases, which cause the effect of "greenhouse" ("greenhouse"), is ultimately responsible for the largest part of the increase of temperatures since the mid-20th century until now.

Climate changes predicted in the 21st century could have major consequences for life on Earth, and even for man himself.

[4]*The strategy of adapting to climate change of low-emission development in Bosnia and Herzegovina*

3.4.1. The natural process of the greenhouse effect

Almost all the heat that the Earth receives from the sun comes in the form of short-wave radiation (100 units). The part of the radiation is reflected from the atmosphere, and the remainder of it is reflected or scattered around the atmosphere,and around48 units goes to the Earth's surface. The atmosphere absorbs about 18 units of solar radiation. The Earth's surface absorbs 43 units of radiation (which the Earth receives from the Sun)so the Earth itself begins to emit radiation. However, as the Earth is a cold body, radiation emitted by the Earth islong wave. It is long wave radiation of the Earth's surface or terrestrial radiation and it amounts to 116 units.Long waveradiation should be added to all other radiation that contributes to the warming of the atmosphere. In total, such warmed atmosphere has 151 units. It radiates long wave radiation. This is called counter-radiation of atmosphere. More specifically, the atmosphere counter-radiationis 96 units and 55 units go into space. Unlike shortwave radiation which is passed by greenhouse gases, long wave radiation is mostly absorbed and re-emitted.

For the greenhouse effect,greenhouse gases are very important. These are all gases that reflect Earth's long wave radiation back toward the Earth's surface and contribute to the greenhouse effect.The most important greenhouse gases are water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (Freon - CFC, Freon-11 CCl_3F; Freon 12 - CCl_2F_2), ozone (O_3) in the troposphere , sulphur dioxide (SO_2), other oxides of nitrogen, carbon monoxide, etc. All of the greenhouse gases in the atmosphere occur in very small proportions. Approximately 60 to 70% of the greenhouse effect is the result of water vapour, 25% carbon dioxide, 5% methane, nitrous oxide, and 2% 1% freon. Other gases have individually less than 1% of the total greenhouse effect.

Most attention in the study of the greenhouse effect is given to carbon dioxide.Its concentration in 1800 was270-290 ppm. CO_2 is the most important gas which causes additional greenhouse effect (approx. 50% of the anthropogenic greenhouse effect). According to the 2001IPCC report, since 1750, there has been an increase in the concentration of CO_2 in the atmosphere by 31%. About 75% of anthropogenic CO_2 emissions into the atmosphere over the last 20 years were caused by the burning of fossil material. Carbon dioxide in the atmosphere is related to the circulation of carbon in nature. It is not known exactly how this abrupt increase in the concentration of carbon dioxide will affect the process of carbon cycling in nature and to what extent of natural oscillations in the system can occur. For the amount of carbon dioxide in the atmosphere its major role iss photosynthesis.

Changes in the ecosystem may also affect these processes. In addition, warming of the sea, as a result of global warming, may result in the release of large amounts of carbon dioxide into the atmosphere.

Today it is considered that by the 2100 the concentration of carbon dioxide in the atmosphere will increase between 50 and 300%. According to some estimates the Earth's surface temperature will increase between 1-5 ° C. For comparison, in the twentieth century temperature has increasedby 0.6 to 0.7 ° C, but this increase was not uniform. A significant rise in temperature was observed since 1976and on average it was 0.18 ° C in a decade. Estimates are, with new knowledge, constantly changing and there is still discussionbetween the connection of the increase in greenhouse gases to therise in temperature. While some scientists are questioning that connection, the vast majority of scientists who deal with climate change confirmed that the increase of greenhouse gases in the atmosphere leads to an increase in temperature on Earth. This is supported by ample evidence: retreat of glaciers, and reduction of surface ice in the Arctic and Greenland's ice sheet, especially in the warm months of the year. Also, it was noted that sea levels are continiously increasingdue to oceans warming and melting ice. Numerous plant and animal species are moving into new habitats due to changes in temperature. The consequences of increasing temperatures on the Earth's surface are difficult to predict. There are various models and most of themshow that there will be changes in weather conditions. Generally the weather will be more extreme. Winters will be warmer, but there is the possibility of a short period of very cold weather. Also, the summer might have huge waves of heat. Undoubtedly the increases in hot days are expected. Higher incidence of natural disasters and tropical cyclones are expected, as well as an increase in their destructiveness.

3.5. The effects of climate change on the sector of fruits, vegetables and table grapes

3.5.1. The effects of climate change on the sector of fruit

Agricultural production in general, and within fruit production is extremely vulnerable to climate change.There are several scenarios of climate change. There are climate change discussions on: reducing the appearance of extremely cold winters and frosts that occur in late spring and early autumn, the extension of the vegetation period, the extension of period with air temperatures above 20 ° C,summer droughts, floods, insufficient quantity and distribution of rainfall during the year , storms and others.These changes have a significant impact on: the growth and development of different varieties of fruit species, in this regard, the possibility of growing certain varieties in a given area, the intensity of the occurrence and spread of various plant diseases and pests, a way of maintaining soil fertility, on yield and quality of yield, which eventually affects the proportion of fruit production in total agricultural production and the socio-economic conditions of a country.

3.5.1.1. Lack of water-drought

Drought is a long period of time when the lack of rainfall has been recorded in a given area, and has a negative impact on ecosystems, agriculture, economy and society as a whole.Damages caused by drought are measured in millions.

Agricultural measures, including irrigation, demands serious analytical approach that begins with determining the needs for a particular measure. When we talk about irrigation, the simplest way is to monitor weather conditions and the occurrence of drought in some area. Occurrence of frequent and longer droughts has become a problem which many experts address. Of course, the main negative consequence is the emergence of hunger and disease. According to the results of some research in the last eighteen years, every sixth year was dry. Furthermore, during the period of 2000-2011, five years have been extremely dry. Results of analysed weather conditions show higher frequency of occurrence of drought and extreme drought years.

Drought resistant fruit trees successfully tolerate a lengthy moisture deficit in the soil and atmosphere, and they do not manifest significant adverse effects in terms of growth and yield.

Some species of fruit trees in accordance with a specific phylogenetic development have very different reactions to drought, classified into four groups:

- xerophytestypes (olives, almonds, etc.),
- semi- xerophytes types (peach,apricot, etc.),
- mesophytes types (pear, plum, etc...),
- hydrophytetypes (apples, citrus fruits, etc.).

Water usage is conditioned: by biological characteristics of the type (variety), age, base, growth stage, etc. For example peach during vegetation period uses five times less water than citrus (13.500: 62.500 l – Stoickov, 1959).

Long term deficit of water leads to the drying of fruits,andthedisturbanceof physiologicalfunctionandreductionof growth andyield. Intermsof long-termdroughtincreasesprotoplasm colloidal andsynthesize of protectivesubstances is set(sugar,mucus, etc.). In addition, fruitsfightagainstdroughtin the following way:

- absorption of water from deeper layers of soil,
- increasing absorption power of roots
- reduction of the root system into shallow layers of soil,
- reducing the intensity of transpiration (improving stoma regulation)
- increasing the thickness of the cuticle and waxy layer on the leaves,
- rising dependency hairiness of leaves and summer growth,
- reacting of stomaorgans at the first signs of water deficit,
- bending and the overthrow of one part of the leaf mass,
- reduction ofells and dense arrangement of larding bundle in leaves,
- changing the structure of the leaves,
- reducing the rate of respiration,
- slowing photosynthesis and other biosynthesis,
- limiting the growth and yield (fruit are falling),
- enhanced activity and reallocating of water
- changing the direction of biochemical processes (hydrolytic processes overpower synthetic processes).

In such circumstances there is an enhanced catabolism of protein in the cell protoplasm, while the transformation of starch and other polysaccharides into lower sugars.The cells of certain organs reduce ability to hold water. On the other hand, the osmotic pressure in cells is increased and suitability of functioning in dehydrated condition is increases.

With the disturbance of the function of protoplasm, an intensification of the catabolicprocess of protein occur and transition of starch to lower sugars, as the ultimate consequence is slowed and the reduced fertility of atree's fruit.These changes can be interpreted as follows:

- in drought conditions trees'fruit better absorb and rationally spending the available water,
- to preserve water, fruits achieve anatomical - morpho - physiological adaptation of cells and tissues because of resulting water deficit.

Some studies suggest the possibility of adapting of fruits to water shortage, with gradual development of resistance to drought during ontogenetic development period. In this sense, more resistant species of fruit trees are ones which in the process of ontogenesis adapted certain water deficit, while at the same having normal fruiting, growth and development.

Ecological environmental conditions and application of phyto-technics significantly affect the resistance of fruit trees to drought, especially in the case of specific physiological characteristics of individual species. The types of fruit trees with leaves more resistant to drying of leaveshave better and longer tolerance to drought without negative consequences. In such types, leaves retain water during wilting period, and also retain the ability to establish turgor after wilting period. In accordance with this process, the faster regulation of all other functions and processes is done. This indicates that the species resistant to drought are also resistant to heat, which cannot be observed separately.

3.5.1.2. Excess of water in the soil - marsh syndrome

In addition to the drought, adversely affecting on fruit has excessive humidity. Conditions of high soil moisture aggravates the physiological activity, root activity, the development of absorptive part of the roots, and often its mortality.High soil moisture in the latter part of the growing season affects the longer duration of vegetation, as well as less lignification of tissues, leading to freezing during early autumn frosts. At high soil moisture there is usually reduced oxygen content necessary for root respiration and CO2 content is increased. This happens in a land with stagnant water, while in terms of regularwater restoring intake of oxygen and CO2 is better, which is why the root of fruit trees quite successfully developed and updated.

Some species of fruit trees respond differently to stagnant water, such as apricots and peaches, which are particularly vulnerable, where damaged root system adversely affects the development of aerial organs and fruit bearing. Conditions of high and prolonged humidity on wet soils can lead to the complete destruction of root and thus the whole fruit.

High humidity in the orchard is causing a number of adverse consequences, such as: aggravated fertilization of fruit trees, less intense photosynthesis, increased development of pathogens, etc.

3.5.1.3. Hager temperatures

Life processes in plants directly depend on the thermal state of the air and land. Because the temperature is one of the decisive factors of the growth and development of fruit trees in certain agro-ecological conditions.As the temperature indicates the thermal state of a body, it is normal that all physiological - biochemical processes must have safe minimum amount of heat, after which all processes cease, and fruits inevitably die. Therefore, it is essential and limited factor of life of certain species of fruits.

The degree of heat in the soil and plant organs directly depends on:

- respiration and transpiration intensity;
- transformation, accumulation and transport of organic matter;
- initiation and duration of certain phenophases;
- absorption of mineral substances from the soil;
- photosynthetic processes in fruits;
- increase, maturation and fruit quality;
- resistance to abiotic and biotic factors;
- land and microbiological processes in the soil, etc.

Significant variation of optimum, maximum and minimum temperature is important as compared to individual species and varieties and in relation to specific growth stages during the growing cycle of fruits. Minimum and maximum temperatures have ecologically critical framework for the geographical distribution of fruit (north, south, subtropical, continental and tropical zones).
Within these zones successfully can be grown only certain types of fruits, as follows:

- south zone: quince, cherry, apricot, peach, almond and walnut,
- northern zone: berries, rowan, sremza, Siberian apple, pear Ussurii etc,
- continental zone: apple, pear, plum, cherry,
- subtropical zone: olives, figs, citrus fruits, persimmons, avocados, etc.,
- tropical zone: banana, pineapple, papaya, mango, coconut, bread wood, etc.

In its phylogenetic development, various kinds of fruit trees have adapted to different environmental conditions and temperatures, within which they have survived to the present day (many are missing). Stronger deviations from the optimal temperature lead to a number of disorders of fruit trees, and often to their drying. For fruit, temperature of land, air and plant organs is of particular importance.Earth is heated by the part of solar radiation; the air is heated mainly by heat emitted from the heated land. The warmingof the air (active surface area) is realized on the basis of molecular conductivity, low-frequency radiation, heat convection and turbulent movement. Land has greatest influence on warming the lowest (ground) layer of air, noting that only a small part of the heat is transferred into the deeper layers of the soil, a certain portion is spent on evaporation.
Constant air movement in the vertical direction leads to higher layers of the atmosphere warming. In each case, the highest temperature is on the surface of the land, and progressively decreases with

its depth, or with the increase in the height of the atmosphere. During the night the land is radiating heat absorbed by water vapour and carbon dioxide, because of this there is no dramatic cooling of the earth and ground layers of the atmosphere.

With the increasing temperatures the assimilation of carbon dioxide increases (to some extent), as well as the process of transpiration, where fruit react by closing stomata. In such conditions, reduction of assimilation of carbon dioxide is present, as well as the production of organic matter. In parallel, there is a higher rate of respiration and decomposition of organic matter, and thus a reduction of spare material in tissues and organs of fruits. The complexity of life processes in fruit trees and their interactions are still not fully clarified and defined. The adverse effect of high temperature may be reflected in different phonological stages and fruit bodies both in the growing season and during the environmental dormancy.

High temperatures during winter dormancy leave a series of negative consequences:

- disruptions in the beginning of the growing season,
- abnormalities during flowering (dispersal of flowers)
- reduced yield,
- occurrence of infertility.

In anextended period (over 7 days),it may cause the activation of cambium and flower buds (especially on the southwest side) which significantly reduces the resistance to low temperatures.

Negative effects come to the front especially in species of fruit with unstable winter dormancy. Stronger temperature fluctuations can cause frostbitten bark and skeletal branches (in the southwest side) even in species with a stable and long winter dormancy. One of the causes of apoplexy apricot is undoubtedly temperature fluctuation in ecological winter rest.

In the budding stage of development, i.e. during gametogenesis in flower buds, temperatures above 30 ° C adversely affect meiosis in male and female primordial cells, causing disruption of conjugation of chromosomes, and the sterility of the hatching cells. High temperature in the flowering stage of development dries stigma and so slows down, and often prevents the germination of pollen. The negative consequences of such actions are even more pronounced in the case of lower humidity and the impact of hot and dry winds. The ultimate consequence is reduced and often completely absent fruit development.

In the summertime, high temperatures cause burns on bark of the trunk and scaffold branches, burns on leaves and fruits, increased evaporation and transpiration (evapotranspiration), etc. The consequences of such actions of the high temperatures are reflected on the number of fruit with extra and first qualities, and often the untimely falling fruit.

At the end of the vegetation period, and during the maturation of late autumn and winter varieties, high temperatures affect the acceleration of fruit ripening, which directly affects the development of fruits and their durability.

Hot conditions for highly intensive fruit growing in Bosnia-Herzegovina are favourable for the cultivation of a large number of continental species and varieties. In this regard, of particular importance are the average daily temperature, monthly and annual temperature, absolute minimums and maximums, frequency of frosts, etc. On the basis of multi-year averages it can be concluded that the temperature sum during the growing season in most parts of Bosnia and Herzegovina is satisfactory for growth, development, optimum yield and timely maturation of fruit. The absolute minimums and maximum temperatures are not a limiting factor for further development of fruit growing in Bosnia and Herzegovina.

3.5.2. The effects of climate change on vegetable sector

Unstable weather conditions have multiple negative effects on vegetable production. The amount and distribution of rainfall are the most unstable climatic factors. Climatic extremes in the form of drought prevents normal growth and development of plants. In drought conditions, water is the limiting factor for the use of the biological potential to achieve a stable and high yield regardless of the high natural fertility of the soil and applied fertilizer. Lack of water reduces availability of nutrients to plants. Increased salt concentration in the soil will lead to adverse effects of minerals, especially nitrogen fertilizer.

High temperatures with a lack of moisture in the soil can cause damages to plants. Some of the stages of growth and development of vegetable crops are set in conditions of optimum temperature, light intensity and moisture content in the soil and air. Deviations from the optimal value of the above factors lead to disorders in the primary assimilation process in which organic matter is created. The increase in temperature up to certain limits increases photosynthesis after which it slows down the process of assimilation and equates with dissimilatory processes of decomposition of organic matter created,and with further increase it will lead to interruption of growth.Vegetablespreferring warm temperaturessuch as watermelons, melons, pumpkins, cucumbers, tomatoes and peppers in relation to other species are more tolerant to the increase in temperature above the optimum value, but in drought conditions dissimilatory processes are amplified that gradually lead to the cessation of photosynthesis and plant death.

High temperatures followed by lack of water may affect the flowering, pollination and fertilization. Pollinators have a problem with flight and operation at high temperatures. Flight of the Bumblebee is difficult at temperatures above 31 ˚ C which reduce the number of pollinated and fertilized flowers. Tomatoes in daily temperatures above 40 ˚ C and night temperatures above 26 ˚ C pestle is extended, stigmas are drying up, reducing the production and germination of pollen and comes to standstill unfertilized flowers. As a result, a small number of smaller fruits are formed which are often hollow because the wells are filled with pulp and have very little or absolutely no seeds. It often occurs in protected areas when conditions are unfavourable for fertilization of flowers. With watermelon and cucumber,because of incomplete fertilization,they develop deformed fruits with little seeds.

In addition to decreasing yields due to adverse effects of climate change on vegetable crops and loss of quality of fruits which manifests itself as a series of morphological changes and deterioration of organoleptic properties. The fruits that are grown in drought conditions have reduced juiciness and vigor. The fruits become coarser and woody, a change in taste, color, size and shape, which reduces their market value. Pepper reacts very negatively to farming in arid conditions, and the fruits are smaller, with less springiness and are very often deformed. The fruits of some varieties of cucumber and eggplant have a bitter taste. Under the influence of high temperatures and intense light premature formation of flower stalks occurs in salads, as well as heads become friable, allowing distortion of the quality. Result of the damaging effects of high temperatures and drought in the cabbage is difficult pickling of heads. High temperatures cause the occurrence of peak rot and blight on tomato and pepper fruits, leaves twisting and cracking tomatoes, etc.


Figure 30: Decay of the paprika plantFigure31:Twisting of tomato leaves
(Source: Sefo, E.)

The green color on the surface of potato tubers and premature outbreak of sprouts may be the result of several factors: a thin layer of soil applied to the tubers, tuber exposure to high temperatures and strong light intensity and age of the tuber.

Figure 32: Green color on the surface of the potato
(Source: Filipovic, A.)

Black heart is a problem with the quality of the tubers as a result of lack of oxygen. High temperatures and excess water in the soil contribute to the state of potatoes. With potatoes,this problem can also develop ifduring storage tubers were exposed to very high or very low temperatures.

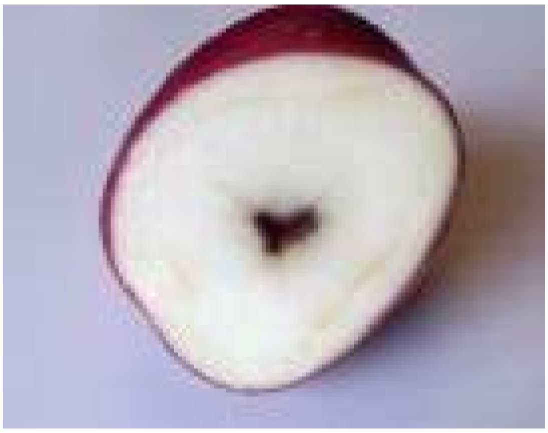


Figure 33:Bleak hart in the tubers of the potato

Under conditions of high temperatures and high intensity light, followed by reduction in the relative humidity,there is an increase in the intensity of transpiration and an increase in plant water requirements. Cabbage in such conditions has a weaker intensity of photosynthesis, and develops small leaf rosettes with fine and coarse leaves and often with a long stem extension within the head. The result of the negative effects of these environmental factors is weak percentage of plants that form the head with less market value.

3.5.3. The effects of climate change on viticulture sector

The area encompassed by this study on the basis of meteorological data is classified in the area with a modified Mediterranean climate. From the standpoint of monthly rainfall, two annual periods are determined, rainy and dry season.The drought period generally coincides with the period of vegetation, and each agricultural production without irrigation, including wine, is very unsafe from the standpoint of quantity and quality of crops.

The needs of the vine for water are different in different phonological stages of growth and development. Critical growth stages for water demand are phenophases of flowering, growth stages and growth and development of berries and phenophases offruit ripening. Lack of water in the beginning of the growing season has a negative impact on plant growth, leaf development and flowering.Lack of water in the flowering stage of developmentleads to poor pollination and falling of flowers. Lack of water in the latter part of the growing season affects defoliation which prevents the collection of nutrients through photosynthesis. Also, the lack of water causes premature aging and a decline in fruit. In the absence of water, the young leaves can subtract water from fruits so fruit remain smaller, dried and very poor in quality. Low yield, quantity and quality, and the damage from lack of water arethe first to be noticed. Due to the small number of leaves and lack of water there is a reduction in the photosynthetic activity and the branches do not have enough food and remain immature. Lack of food affects the differentiation of buds which are carriers of the green mass and yield in the following year. Immature seedlings are sensitive to frost and suffer from frost at higher temperatures (higher than those at which mature shoots suffer from frost). Repeating of this process for the next vegetation leads to deterioration of parts of the plant, the entire plant or series of plants, but also leads to significant shortening of a vineyards life span.

Increasingly frequent occurrence of drought and their longer duration in these areas have led to the point that agricultural production can be carried out only in irrigated areas. High temperature above 35^0C if it lasts longer, and without the occurrence of drought in the vineyards can cause similar damage.

4. DROUGHT AND ITS IMPACT ON AGRICULTURE

4.1.Definition and types of drought

The United Nations urged nations (2013) to strengthen national measures to combat drought after warning of how climate change may increase the frequency and severity of these natural disasters.

Droughts in the world claim more lives and cause increased migration of the population than do floods or earthquakes, which means they are the most destructive natural disasters (FAO, Geneva, 2013).

The United States,in 2012,has been hit by the strongest drought sincethe 30’s of the last century, which raised grain prices to record heights. Droughts in recent years hit the Horn of Africa and the Sahel region, as well as China, Russia and South East Europe (Bosnia and Herzegovina).

State governments of the world are slow to react to the problem which drought brings. Unlike other natural disasters, they are quite slow to react and rarely the public is alerted about the droughtin a timely manner.Four UN agencies: FAO, WMO, UN Convention to Combat Desertification and the Decadeof UN Programme for Development of water capacity - launched the "National Initiative for drought management policies."

Figure34:Consequences of drought (Source: FAO, 2013)

Drought in many areas isa common occurrence that repeats itself with no apparent regularity.Although one can encounter it in almost all parts of the world, its characteristics vary from region to region. Defining drought is therefore difficult and depends on regional differences and needs, but also from the perspective from which this phenomenon is observed.

Based on the many definitions that have appeared in the literature, we could define a drought in Africa, for example, as "a phenomenon that occurs when the annual rainfall is less than 180 mm", but in Indonesia, drought can be "considered a situation in which the six days there is no raining!“

In the broadest sense, the drought is the result of a lack of rainfall over an extended period of time, leading to water shortages for some activities, group activities, or the whole sector in one environment. Whatever the definition, it is clear that the drought cannot be viewed only as a physical phenomenon.

At the beginning, it is useful to note the difference between aridity and drought:

Aridity of a region indicates that there is a constant shortage of rainfall compared to normal or necessary values (in some regions, lack of rainfall so long that these small values become normal) in that region.

Aridity is characteristic of the climate of an area. On the other hand, drought is, usually short-term deviation due to amounts of precipitation and air temperature measured from the normal value for a given area and time of the year.No matter for which needs drought isdefined, it is essential that definition includes the deviation of the current relationship between rainfall and evapotranspiration on a range of normal values of this ratio for a given multi-year data series.

It is also important to consider the temporal distribution (rainfall regime, delay of the start of the rainy season, the relationship between the occurrence of rainfall and vegetation phase of major field crops in the observed area) and the efficiency of precipitation (rainfall intensity, number of rainy days). Other climatic factors such as high temperature, high speed and strength of the wind and low relative humidity are often associated with the occurrence of drought in many areas of the world and can significantly aggravate its consequences.

Drought should not be viewed only as a physical phenomenon and natural phenomenon. Its influence on the whole of society is the result of interactions between natural phenomena (lack of rainfall compared to the expected value, which is the result of natural climate variability) and requires people to constantly supply water. People often exacerbate the effects of drought. Droughts that in recent years have hit developed and developing countries had a significant impact on the economy and the environment of these countries by enhancing the vulnerability of the society to this natural disaster. In principle, there are conceptual and operational definitions of drought.

Conceptualdefinition of drought is formulated in general terms and is intended to help people understand the concept of drought. It can be said that the drought is an unusually long period with a deficit of rainfall leading to extensive damage to plants and reduction of yields. Conceptual definitions are also important in developing strategies to combat drought. For example, Australia has a strategy that assumes that the drought caused by normal climate variability and financial assistance to farmers is granted only in the case of "exceptional drought conditions" when drought is more intense than "normal". The term "normal" drought is for certain areas defined on the basis of scientifically based studies. In this way, situations are avoided in which producers, due to lack of well-defined conditions, every few years sought support from the government to redress the damage caused by drought.

The *operational* definition of drought should help facilitate the definition of the beginning and end of drought intensity. The start of drought is usually defined as the moment in which rainfall, or other relevant climatic element in a certain amount deviates from their medium or normal values for a given area. This is usually done by comparing the observed values of meteorological elements from its 30 year annual average. Deviations from limit values, for many purposes, unfortunately, more often than normal is estimated rather than determined based on the precise relation between the individual effects and / or parameters that describe the drought.

One of the *operational*definitions of *agricultural drought* is based on a comparison of daily rainfall and evapotranspiration intensity to determine the intensity of the reduction of moisture content in the soil. Then this relationship will be connected with the behaviour of plants (vegetation dynamics and yield) in different vegetation stages.

One such definition could be used for operational assessment of the intensity of droughts and their effects with monitoring of meteorological elements, the moisture content in the soil and plant growth and development during the growing season, with continuous correction of the influence of these factors on the yield of the harvest/fruit picking. The operational definition of drought can be used to analyse the frequency, severity and duration of drought observed during the historical period. However, these definitions imply hourly, daily and monthly meteorological data as well as data indicating the effects of drought on, say, agricultural production (change in yield components and the like). Detailed knowledge of the climatology of drought in a region provides a better understanding of its characteristics and the probability of repetition with different intensity. Information of this type is extremely useful in developing strategies to combat the negative effects of drought.

*Meteorological drought.*Meteorological drought is usually defined by the degree of aridity (compared with normal or average values for the selected period) during a dry period. The definition of meteorological drought is linked to the region; due to the atmospheric conditions that lead to rainfall differentiation dramatically from region to region. For example, some definitions of meteorological drought are based on identifying the period in which the precipitation was less than a lower limit value. This definition is appropriate only for areas which are characterized by a certain rainfall regime throughout the year, as is the case in tropical rain forests, humid subtropical climates or humid climates temperate latitudes. In other types of climate, characterized by a lack of rainfall over a longer period of time, the definition of drought based on the number of dry days is quite inapplicable. Some other definitions of meteorological drought are usually associated with the accumulated amount of deviation from the average values of rainfall for the month, season or year.

*Agriculture drought.*This term connects the different characteristics of meteorological (or hydrological) drought with their impact on agricultural production, focusing on the reduction of rainfall, the difference between actual and potential evapotranspiration deficit of moisture in the soil, reducing the groundwater level, etc. The requirements for water in plants depend on weather conditions, biological characteristics of plants, stage of development, as well as the physical and biological characteristics of the soil. The correct definition of drought should take into account the variable sensitivity of plants to drought in various stages of its development from emergence to full maturity. The deficit of moisture in the topsoil at the time of sowing can make it difficult to germinate, leading to a reduction in the number of plants per unit area, and thus to a reduction in yield. However, if the moisture content in the surface layer of soil is sufficient for normal growth and development of plants in the growing period, the deficit of moisture in the deeper layers of these phases will not affect the yield at harvest time if the moisture supply is replenished during the vegetation period or if precipitation meets the needs of plants for moisture.

Hydrologicaldrought.This drought has been associated with the occurrence and effects of the lack of rainfall in overhead and underground reservoirs (lakes, groundwater and artificial reservoirs). The frequency and intensity of hydrological drought is often defined at the level of its basin area. Although the cause of droughts always lies in the lack of rainfall, hydrologists are much more interested in how this will affect the overall lack of hydrological system. The occurrence of hydrological drought is often a phase shifted, i.e., there is a significant delay in relation to meteorological and hydrological drought. It takes a long time to show the effects of lack of rainfall within the elements of the hydrological system in terms of reducing the moisture content in the soil, reduced water levels in rivers and overhead and underground reservoirs. For this reason, the economic effects of hydrological drought in all spheres is felt after those caused by meteorological drought.

For example, the deficit of rainfall can cause a lack of moisture in the soil, which, along with their effects, are currently visible to the agronomists, but which will affect production of electricity only a few weeks or months later.Also, water from water reservoirs is used for different purposes (irrigation, tourism, flood control, electricity generation) so the further analysis of the effects of hydrological drought is more complicated. During the drought, the need to use water from reservoirs is escalating leading to conflict among users of these stocks.

Although the weather is the primary cause of hydrological drought, other factors such as land use (excessive deforestation, for example), and land degradation or embankments, may affect the hydrological characteristics of the observed basin. Given that the regionsare interconnected hydrological systems, the effect of hydrological (and meteorological) drought can significantly extend beyond the place where it was created. Also, changes in land use may affect its hydrological characteristics such as infiltration and runoff intensity, leading to greater variability in water flow and greater probability of hydrological drought in the downstream region. Changes in land use are an example of how human activity can affect the frequency and intensity of the lack of available moisture (water), even when there is no meteorological drought.

When the drought starts, the agricultural sector is usually the first to come under threat because of its exceptional dependence of moisture content in the soil which can decrease rapidly if the dry season continues. If duration of the rainfall deficit is present, then the other sectors that depend on the available water resources are targeted. Depending on the previous water supply and hydrological characteristics of the system, if the drought is short (3-6 months), sectors that depend on water supplies in overhead and underground reservoirs will be least affected by drought. However, if the drought continues these reservoirs will be emptied. At the same time, it should be noted that recovery form drought is fastest in sectors that fastest react to it, while those who are slower to react (hydrological systems) need more time to recover.

In the medium (mountain) parts of the country, in the last 50 years there have been three extremely dry periods. Northeast and southwest of the country has significantly increased risk of drought, meaning that in the last 50 years, there were seven extremely dry periods.Droughts were also more frequent and more intense over the past decade: since 2000 there were five years of drought (2000, 2003, 2007, 2011 and 2012). Although a detailed study was not carried out on the topic of predicting droughts, more frequent and more intense droughts are worrisome because they represent a clear indication of increased climate variability.

Damage from a natural disaster may be declared with long-term consequences of water shortages in the system ofsecuring the supply of water, which appear as the limitationfor development, production decline, epidemics, etc.

In the plant production, drought as a natural disaster occurs when moisture deficits incurred during the preparation for sowing or, in certain stages of the growing cycle of the plant. In doing so, the decisive role is played by the overall water balance of the plant, and in it only indirectly hydrological balance. Requirements of the plants define the term drought.It is not uncommon for a hydrological arid period to cause an occurrence of natural disaster like drought.

Depending on the climatic characteristics of the area, crop rotation, drought can occur in different seasons and with different intensities. Therefore, in a Mediterranean climate the period when a drought can occur lasts 5-6 months a year, and in karst areas and northern parts of the country in the period between August and November (3 months).

The total balance of water in the Mediterranean part of Bosnia and Herzegovina should be at the level 120-240 million m^3 of water and in other parts of Bosnia and Herzegovina 300-600 million m^3 of water. Natural disasters will occur if during the dry years 120 to 300million of m^3 of water for about 230,000 ha once in 10 years, and damage from water deficit could cause yield reduction of 5-30% on some cultures and in certain areas.

The intensity of drought is usually estimated with the reduction of yields, provided that the other adverse factors did not have affect. If the yield decreased up to 20% it is a weak drought, 20-50% medium drought, and over 50% heavy drought.

The occurrence of drought is most common in Herzegovina in the summer months. Given the intensity and duration, it is particularly present in southern Herzegovina.In the flat part ofB&H

drought is less notable than in Herzegovina, while the least prevalent is in the mountainous part of B&H.

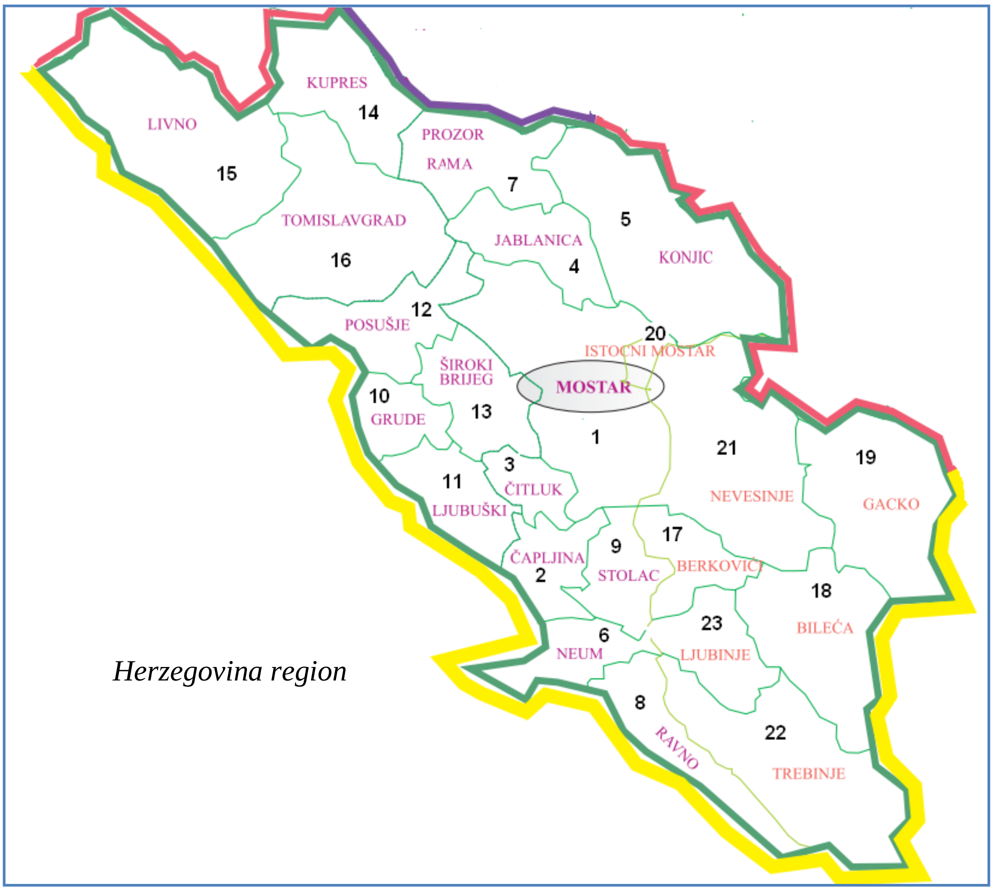


Figure35: Herzegovina region

4.2. Factors that influence the occurrence of drought in agriculture

Climate of Herzegovina has Mediterranean to sub Mediterranean features. However, the distribution of rainfall and temperature in this area is characterized by two opposite seasons: moderately warm and very abundant winter rainfall and hot and dry summer, which the climate of this region provides more arid than humid character.

The plants most of the water takesfrom root system from the soil, although it is possible to adopt the water though the leaves and all other organs (if not covered by a thick cuticle or bark). A rough estimate of the availability of water is usually expressed with aridity index according to De Martonn-in:

$$\text{Aridity index} = \frac{\text{total rainfall (mm)}}{\text{average annual temperature (C) +10}}$$

If the aridity index is less than 20, area is arid. The index of aridity can be used to assess the aridity per month of vegetation:

$$\text{Monthly Aridity index} = \frac{\text{monthly rainfall (mm) x 12}}{\text{average monthly temperature (C) +10}}$$

The index of aridity for the wider area of Mostar is 57.7 which lead to a wrong conclusion. If monthly aridity index is taken into account, two very dry months can be observed(July and August 12.9 17.6) and in the growing season.

*Table9:*Monthly aridity index - *Mostar*

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
106,0	95,3	70,7	53,9	44,1	26,3	12,9	17,6	39,0	79,5	116,5	152,4

Drought can be displayed in two ways: by the amount of lack of water in the soil (mm) and over the relationship between actual and potential evapotranspiration, and with so-called "coefficient of drought." The average annual water deficit in the soil in Bosnia and Herzegovina is about 125 mm,with the largest in the southern parts (300 mm), considerably lower in the northern (100 mm), and lowest in the central parts (50 mm). Agriculture must be protected not only from the average drought, but also those that occur once in ten years. Therefore, we must take into account the frequency of droughts.

The highest coefficients (4.0) are in those areas (central) where we have the lowest average values. In contrast, the lowest coefficient (1.67) is in those regions (southern, Hercegovina) in which the average value is the highest. In considering the drought, taken into account are atmospheric and soil drought, using the method of water balance of the soil.

The frequency of drought

The greatest risk of drought in Bosnia and Herzegovina is in the northeast and southwest. In the last fifty years, there were seven extremely dry periods. It was found that the strongest droughts occur in the area of Mostar, where a catastrophic drought was recorded in the 1952 with an annual deficit of water in the soil of over 400 mm. Very mild drought has an area of Bihac or none at all. Other locations lie between these two. Descending order of frequency of drought that occurs once in ten years is shown in the following table:

Table10: Annual deficit of water in soil in (mm)

Location	***Annual deficit of water in soil in (mm)***					
	0	1 -100	101 - 200	201 - 300	301 - 400	>
	Intensity scale					
	No drought	Very mild drought	Mild drought	Strong drought	Very strong drought	Catastrophic drought
Bihac	17	10	3	0	0	0
Banja Luka	12	12	4	2	0	0
Brod	4	8	13	5	0	0
Bijeljina	3	6	13	7	1	0
Tuzla	12	13	2	3	0	0
Livno	6	17	5	2	0	0
Sarajevo	8	11	10	1	0	0
Mostar	0	8	9	10	2	1

(Source: Risk Assessment ofB&Hfrom natural andother disasters, 2011)

It is evident that from the observed eight locations the most vulnerable area with drought is Mostar, and a very endangered areais Livno. Both of these cities are located in the respective region of Herzegovina. For agriculture, droughts that occur during the vegetation period are threatening, due to a reduction or complete absence of yield. As well,there are particularly dangerous droughts in the south of the country which cause the spread of forest fires.

Precipitation

Precipitations between meteorological elements have a dominant influence in crop production. Choice of tillage systems and related systems of crop production can partially mitigate the lack of rainfall in areas where there isa deficit, and it is possible to have some impact in terms of reducing the negative impact of excessive amounts of precipitation in humid areas and semi-humid. Results in crop production are closely tied to the amount, distribution, frequency and intensity of rainfall.

Area of Herzegovina is very rich in rainfall (an average of 1000-1500 l/m^2/year.), which in extreme cases reaches up to 5,000 l/m^2/god. However, rainfall is not evenly distributed throughout the year. The highest rainfalls have been registered in winter-spring, so the growing season are when floods occur in existing karst fields and the least rainfall occurs during the summer period.

From the example in the period of winter rainfall 2009/2010 the meteorological stations of Republic hydro meteorological institute of Republic of Srpska (Figure 36) it can be seen as of the total rainfall in the Republic of Srpska, 41%,is only on five stations in the eastern part of Herzegovina. So in the Gacko municipality, for the period, fell 1,145 l/m^2, in Nevesinje 1032, Trebinje, 1015, Cemerno 1012 and Bileca 1006 l/m^{2}of precipitation. For the same period Banja Luka had just 414, and Prijedor 324 l/m^2.

For this area of Herzegovina region it can be said to have a very high total annual rainfall but it isunfavourablydistributed with respect to the need for water in agriculture.

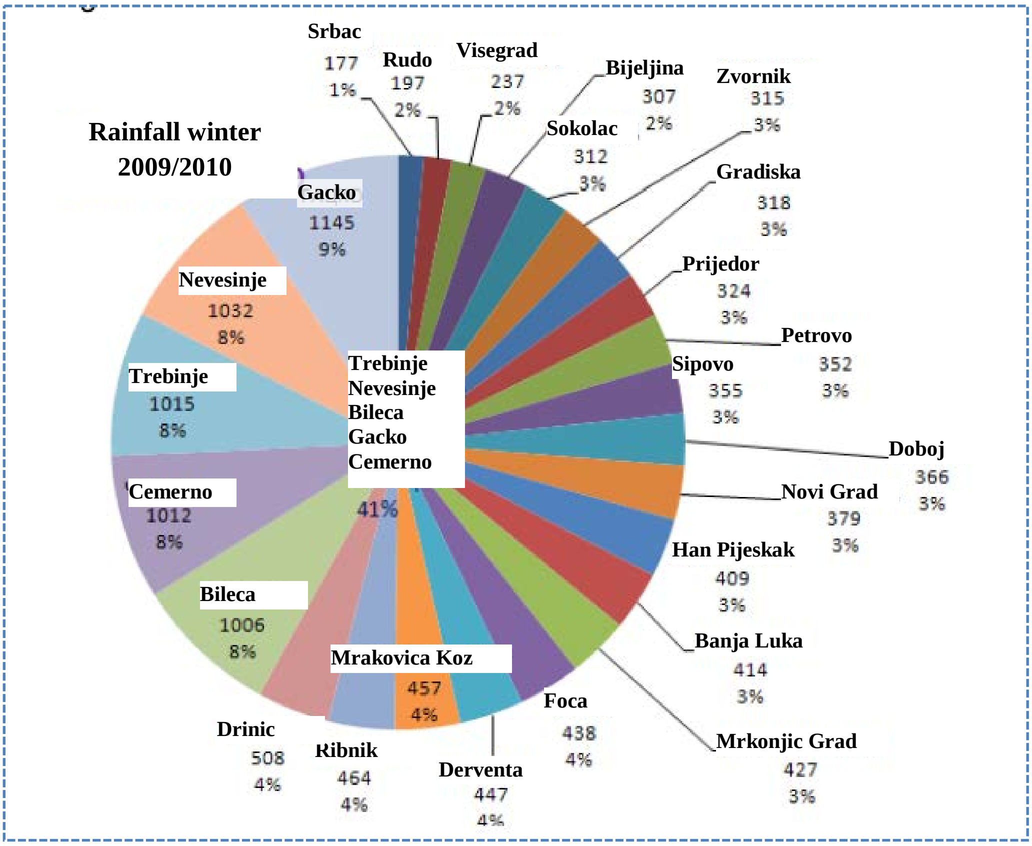


Figure36:Spatial distribution of rainfall in Republic of Srpska in winter 2009/2010 (Source: Hydrometeorological institute of Republic of Srpska)

Table11:Amounts of rainfall and temperature for the municipalities of east Herzegovina compared 2012 and average for the measurement period 1981-2010 seasonal and annual data

Meteorological station	Period	Amount of rainfall (l/m^2)					Ground air temperature (^{0}C)				
		Annual	Spring	Summer	Fall	Winter	Annual	Spring	Summer	Fall	Winter
Bileca	**1981.-2010.**	1.539	359	179	173	481	12.3	11.4	21.3	12.7	4.1
	2012.	1.547	404	43	172	494	12.9	11.9	24.0	14.5	2.0
	±	8	46	-136	-2	12	0.6	0.5	2.7	1.8	-2.1
Gacko	**1981.-2010.**	1.601	374	189	178	503	8.4	7.6	17.0	9.2	-0.4
	2012.	1.590	393	44	237	481	9.1	8.2	20.2	11.1	-2.2
	±	-12	18	-146	59	-22	0.7	0.6	3.1	1.9	-1.8
Trebinje	**1981.-2010.**	1.577	336	176	184	515	14.4	13.0	23.0	15.0	6.4
	2012.	1.821	410	79	191	585	15.4	14.0	26.3	17.1	4.8
	±	244	74	-97	8	70	1.0	1.0	3.3	2.1	-1.6
Cemerno	**1981.-2010.**	1.663	400	218	180	506	6.2	5.1	14.5	7.0	-1.8
	2012.	1.663	469	91	203	551	7.0	5.7	17.6	9.7	-4.4
	±	0	69	-127	24	45	0.8	0.6	3.1	2.8	-2.6

(Source: Hydro*meteorological* institute of Republic *of Srpska)*

Although the amount of annual rainfall has not changed significantly, the number of days in the year during which the observed precipitation is reduced has been decreased, but at the same time there is increased in the number of days with intense precipitation.This represents a significant change in precipitation patterns, especially in combination with increasing temperature. The result of these changes will be less soil moisture (potentially increasing the frequency and magnitude of droughts)and the increased likelihood of flooding, due to the increase in the frequency of intense rainfall.

During the period of the 1981 increased variability has been observed during all seasons and throughout the whole country. For example, there was a trend of rapid change from extremely hot or cold periods, which usually last from 5-20 days in periods of intense rainfall. There were also a growing number of hail conditions and increased levels of maximum wind speed in the central parts of the country. Between 1981 - 2010 a large part of Bosnia and Herzegovina has shownthe trend of a slight increase in annual precipitation compared to the period 1961-1990. The largest increase in annual rainfall is recorded in the central mountain areas (Bjelasnica and Sokolac) and near Doboj, while the largest deficit was recorded in Herzegovina (Mostar and Trebinje). The largest decrease in rainfall was recorded during the spring and summer in Herzegovina (20%).

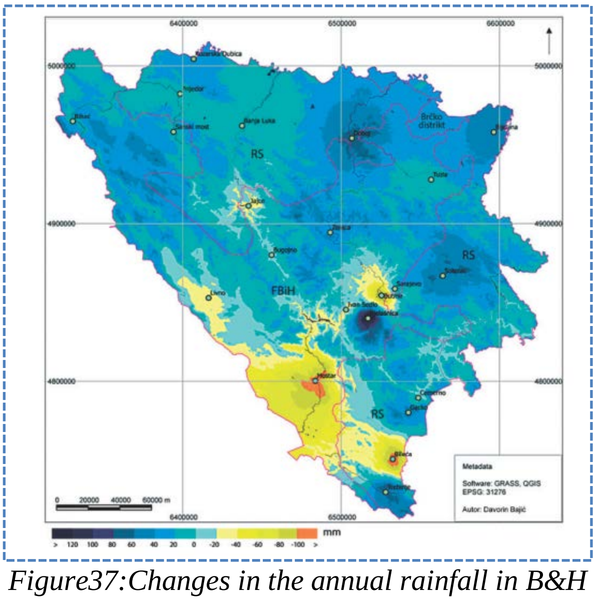


Figure37:Changes in the annual rainfall in B&H
(Period 198.-2010with period 1961-1990)
(Source: Second national report B&H for UNFCCC)

Temperatures

Initial National Communication (INC) and the Second National Communication (SNC) on Climate Change recognize the fact that climate change is affecting the B&H and the fact that these changes will occur rapidly until the end of the 21st century. Studies on temperature changes during 1961-2010 indicated that the temperature has increased in all parts of the country. During the period 1981-2010 the largest increase in the average temperatures of the summer months are recorded in Herzegovina (Mostar 1.20 C), while the largest increase in temperature during spring and winter recorded in Banja Luka 0.70 C.

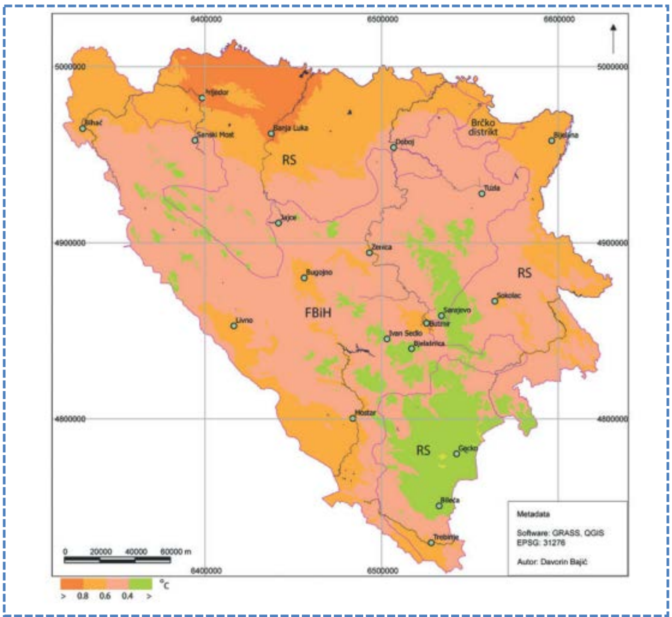


Figure38:Changes in the annual temperature in B&H
(Period 1981-2010 with period 1961-1990)
(Source: Second national report of B&H for UNFCCC)

Index of drought

Index of drought are often expressed by only one number but it can provide much more useful information for predicting and combating drought of raw or measured data. There are several indexes that show how rainfall and its distribution in the reporting period deviates from the annual amount of rainfall for at least 30 years for a given time unit. Although no single index can be declared superior over the other(s), some are more frequently applied, tested and calibrated in different regions and for different plant species than others. Most experts dealing with the planning of water resources, primarily in agriculture (irrigation) usually base their decisions on a number of different indexes.

a) Percentage deviation from the norm (percentiles)

This index is often used in the media.Its advantage is that it is easily applied to different spatial and time scale and is suitable for the respective comparisons. The disadvantage is that it can easily lead to misunderstandings and misinterpretations because what is considered normal in meteorology often does not coincide with the usual, i.e. the expected conditions. Percentage deviation from the norm is calculated as the ratio of the actual and normal (annual value for a continuous series of at least 30 years), and the rainfall in the observed time interval is multiplied by 100%. It can easily be determined for any time unit, including phenological stages, the growing season or the hydrological year.

b) Standardized Precipitation Index SPI (Standardized Precipitation Index)

SPI is an index based on a calculation of the probability of precipitation for the selected time period. Many users of this index valuethe flexibility of this index when it comes to spatial and time scales on which to apply this indexso it is in a wide practical use. Its advantage lies in the fact that despite the fact that it can be counted in different time scales, SPI can provide early warning of drought and help in assessing the intensity of drought.

Table12: Classification of drought according to SPI index

SPI index	
2.0 and more	Extremely humid
1.5 do 1.99	Very humid
1.0 do 1.49	Modestly humid
-0.99 do 0.99	Weak drought
-1 do -1.49	Modest drought
-1.5 do -1.99	Strong drought
-2 and less	Extreme drought

Positive SPI values indicate that the observed precipitation is greater and negative values indicate that the actual rainfall is less than the median. Using data from the table with the values of the SPI index and the corresponding features, it can be concluded that this index provides not only information on the severity of the drought (which corresponds to the value when the index is less than 0) but also on its duration. Because it is considered that the drought period begins when the index falls below 0 and lasts until it becomes positive.

Depending on the climatic characteristics of climate, drought can occur in different seasons, and with varying intensity. In the Mediterranean climate drought may last for 5-6 months a year, in the northern parts of the country and karst fields it may last three months (August - October).

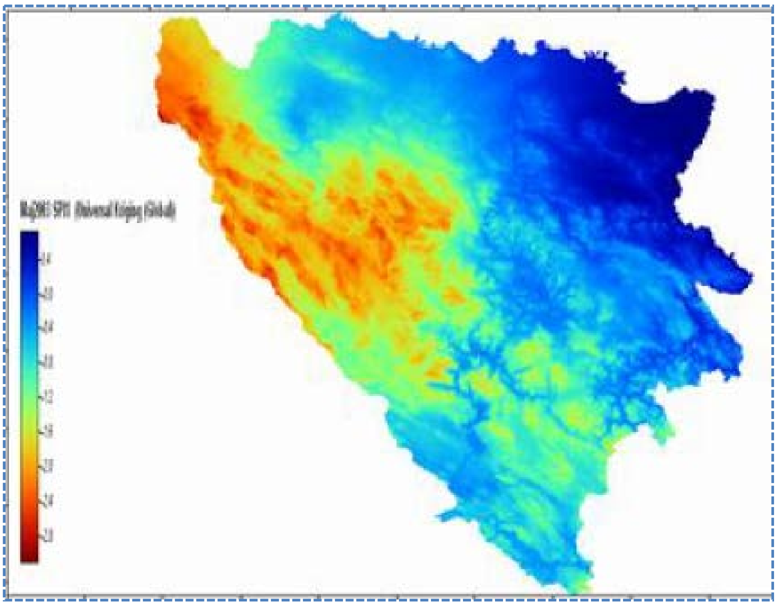


Figure39: SPI 1 indexfor May2003
(Source: Risk Assessment ofB&Hfrom natural andother disasters, 2011)

In the area of northern Bosnia during the period spring - summer 2003, a drought was recorded that was more intense thanone observed during the 2000. Lack of rainfall in the summer of 2003 has caused a hydrological drought, which is manifested by reducing the surface and deep water reserves. Analysis of drought based on SPI index shows an increase in years of drought in the last decade.

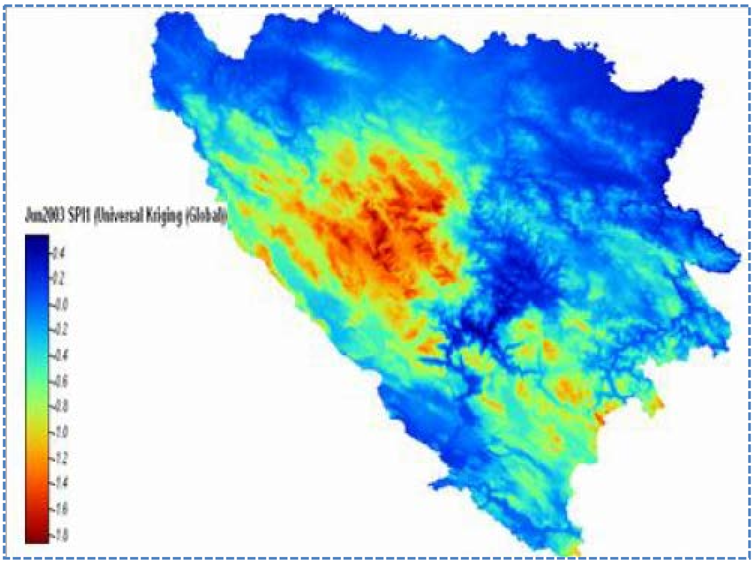


Figure 40: SPI 1 indexfor June2003
(Source: Risk Assessment ofB&Hfrom natural andother disasters, 2011)

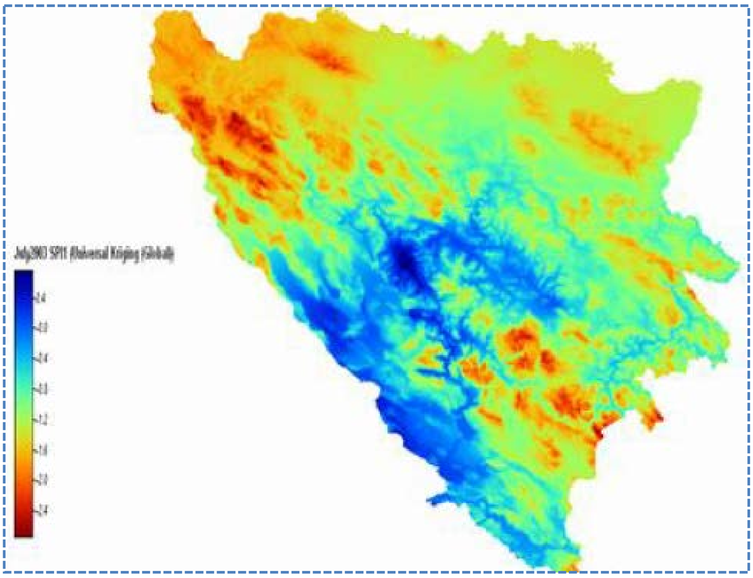


Figure 41: SPI 1 indexfor July2003
(Source: Risk Assessment ofB&Hfrom natural andother disasters, 2011)

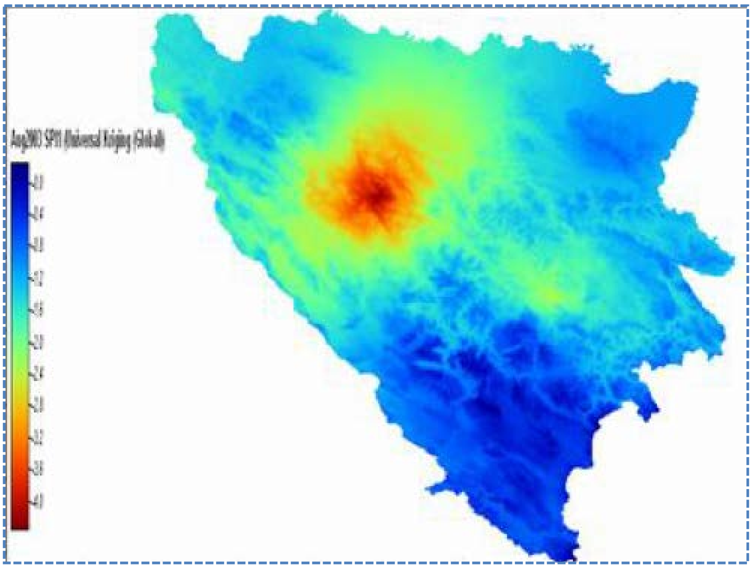


Figure 42: SPI 1 indexfor August2003
(Source: Risk Assessment ofB&Hfrom natural andother disasters, 2011)

In Figures 39-42 the changes in one SPI drought index for May, June, July and August are present for an exceptionally dry 2003.

SPI 1 index value for the month of May show that the area of western and south-eastern Bosnia had moderate, severe to extreme drought, while other parts of Bosnia were in the category of mild drought.Livno, Mostar and Gradacac for the first two decades of May did not have even a drop of rain. Only in the third decade of May 2003 were observed precipitations that somewhat mitigated drought.

SPI 1 index value for the June 2003 year in most parts of the country were in the category of moderate and severe, and in the end of northwest, northeast and southeast were in extreme drought (Bihac, Sanski Most, Gradacac). In central, southern and south-western parts SPI1 were in the category of mild drought.

For the month of July 2003 in the far northwest, west and southwest of the country SPI 1 was in the category of moderate to severe extreme drought, while the rest of the country was in the category of mild drought.

In the central parts of the country during August 2003 a large deficit of rainfall was recorded. SPI 1index value in the central parts were in the category of moderate to extreme drought, while for the rest of the country index was in the category of mild drought.

Wind Speed

For climate of Herzegovina special significance has the north wind (bura) and southern wind (jugo).Bura (southern wind) is a strong, cold and dry wind blowing at high speed in the fall, winter and early spring. With strength, speed and dryness it affects very fast drying of the soil and makes climate much drier than it is expressedin rain factors.In addition, the power and speed of blowing carries large amounts of the smallest particles of dry soil at large distances. In this part of Herzegovina eolian erosion is very apparent, which comes partly thanks to the whole complex of almost bare rock. Jugo (South wind)is morefavourablewind for climate and vegetation as it is hotter and drier and brings rain, and has lower intensity of blowing.

Wind influence in agricultural production is multifaceted due to the fact that wind is a swirling and turbulent flow of air, its action alternates temperature, carbon dioxide and water vapour in the atmosphere, and accelerates the transfer of pollen, spores and seeds. Weaker-to-moderate winds will have a favourable effect on photosynthesis because it will speed up the flow of carbon dioxide to plants, while stronger winds may adversely affect in terms of increased evapotranspiration. Wind is possible to define by direction, speed and strength. Wind direction tells where the wind is blowing, and in general it can be said that the wind is directed from higher to lower pressure fields. Speed also depends on the air pressure so that the areas in which these differences are big in short distance are subjected to intense and stormy winds. Wind speed is evaluated without the instrument, and between it and the speed there is a functional relationship. Wind strength is evaluated by the Beaufort scale, which ranges from 0 to 12 degrees. For example, 0 degrees is the silence, first degree - light breeze (breeze), and the 12th stage - a hurricane. The area has an average annual wind speed of 3.6 m / s (Fig. 43)

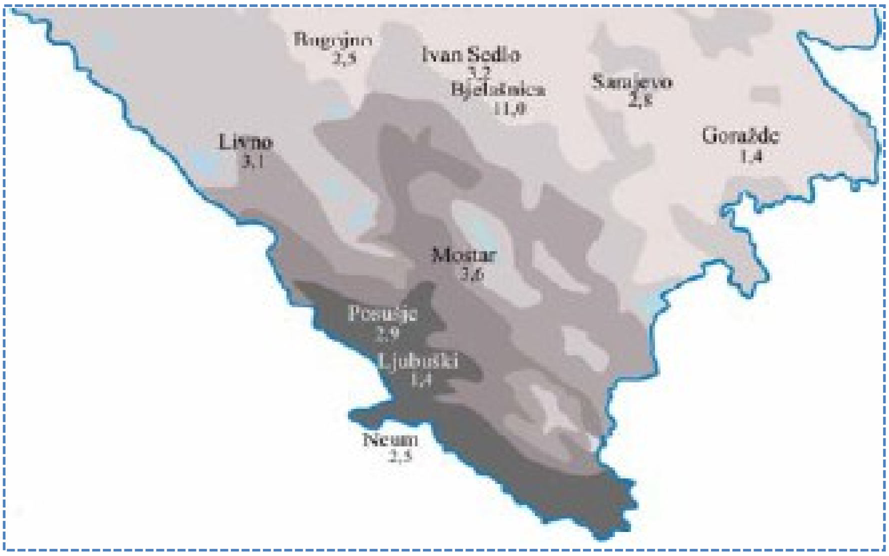


Figure 43: Average annual wind speed

Table 13: Average wind speedsinthe region of Herzegovina(period1949-1953)

Wind direction	**Winter (m/s)**	**Spring (m/s)**	**Summer (m/s)**	**Fall (m/s)**
N	5,5	4,5	3,9	4,7
NE	11,7	5,8	4,4	5,9
E	5,5	4,4	3,8	4,4
SE	3,1	4,0	2,5	2,4
S	4,0	3,2	2,9	3,2
SW	2,9	2,8	3,0	2,4
W	2,6	2,4	2,6	1,9
NW	3,2	2,7	3,4	2,8

MeteorologicalstationMostar

Tabular overview of the frequency and average speed of particular wind directions
Period: Multi annual string

Direction	C	N	NE	E	SE	S	SW	W	NW	SUM	AVERAGE SPEED
Freq. (u %)	10,2	24,2	18,8	6,2	4,3	9,6	11,3	6,4	9,0	100,0	
Speed m/s)		4,6	4,7	4,0	2,0	2,6	2,5	2,4	3,1		3,3

C =Silence

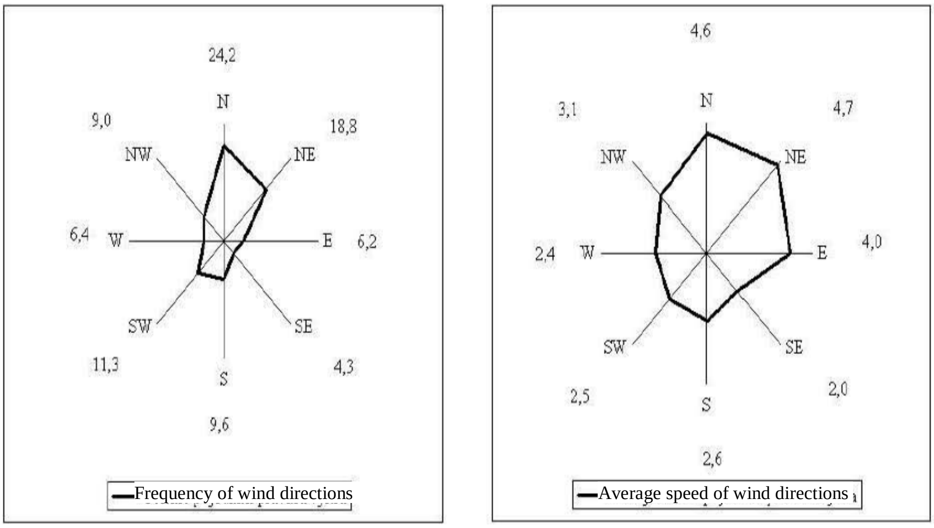


Figure 44: Showingthe frequency and certain averagespeedsandwind direction for Mostar

Rose Wind for Cemerno

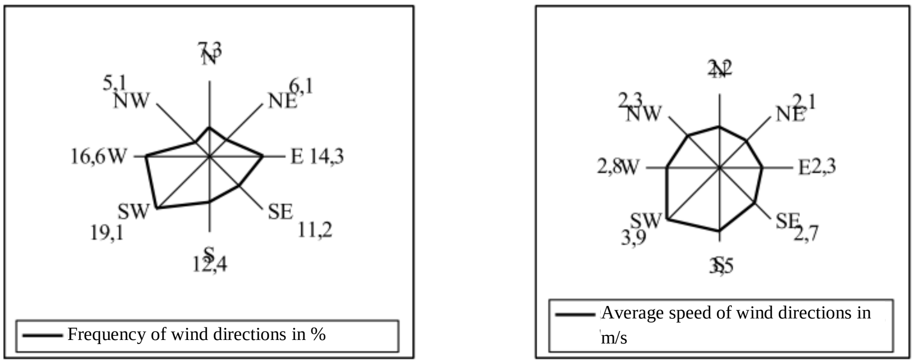


Figure 45:Showingthe frequency and average speed of certainwinddirection for Cemerno

Rose Wind for Trebinje

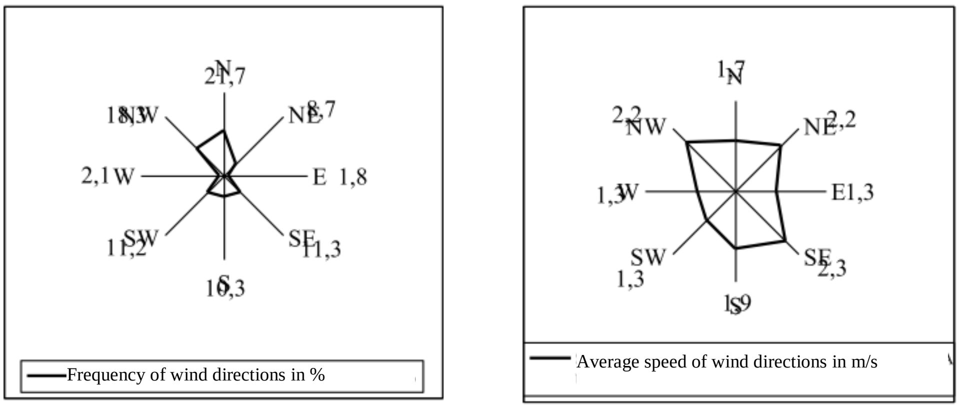


Figure 46:Showingthe frequency and average speed of certainwinddirection for Trebinje

Table14: Annual numberof days withstormywind andthe maximumwind speed (1961-1990)

Meteorologicalstation	Annual number of days with wind stronger than 8 Beaufort	maximumwind speed(m/s)
Bugojno	9,8	29,6
Ivan sedlo	37,8	38,5
Livno	31,3	37,4
Mostar	42,8	44,2
Bileca	7,9	33,0
Cemerno	24,1	41,4
Trebinje	5,0	---------

(Source: Risk Assessment ofB&Hfrom natural andother disasters, 2011)

Insolation

This area ischaracterized by highinsolation. On the territory ofBosnia and Herzegovina, Mostarareahasthe longestdurationof sunshinewith an annualaverage of2308hours(1952-1962.). In the analysed period,the average monthlyanddailyvalues were(hours):

Table15: Monthly insolationin the Mostar area

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
110,2	120,4	170,9	181,8	234,7	275,6	339,8	324,7	241,0	179,2	103,5	81,6

Table16:insolationin the Mostar area

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
3,5	4,3	5,5	6,0	7,6	9,2	11,0	10,5	8,0	5,8	3,4	2,6

These data suggest that there is great potential for thermal energy and this is an area suitable for the production of many crops in the open, especially for greenhouse production.

4.3. Variability of climate parameters during the year

Municipalities that are the subject of this study are located in the moderate zone of the northern latitudes. General characteristics of the moderate climate zone are distinct differences in four seasons. In the area of the municipality, modified Mediterranean climate is present, because this area is exposed to the Mediterranean climate of the south and the mountainous continental to the north. The influence of the modified Mediterranean climate is no longer expressed in four seasons, but the characteristics of the climate are two prominent periods characterized as bright, dry summers and mild, rainy winters. Annual variation of climatic parameters of temperature and precipitation changes, we will analyze the meteorological station of Mostar in 2011, and comparing it with the same climatic parameters for the period 2000 to 2010 on the same meteorological station.

4.3.1. Air temperature

Annual variability of temperaturesare analyzed on the basis of data on average monthly, absolutely maximal and absolute minimum air temperatures and thermal labels climate according to Gracanin.

Table 17:Average monthly, annual and vegetationtemperature(Mostar) for theperiod *2000 -2010 and 2011*

Year				**Vegetation**									
	Month											**Average**	
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	**year**	**veg.**
2000-2010	5,5	6,8	10,3	14,7	19,9	23,7	26,4	26,1	20,2	15,8	10,7	6,7	15,6	21
2011	5,8	7,8	10,0	15,8	19,6	24,7	24,9	27,2	24,9	15,2	10,3	7,8	16,2	21,8

The difference between the highest average monthly temperatures in the month of July and the lowest monthly average temperatures in the first month of the 2011has been 21.40 °C, and the same difference for a period 2000-2010 is 20.90 °C. The average annual temperature for the 2011 was 0.60 °C higher than the same temperature for the period of 2000-2010. The averagevegetation temperature for 2011 increased by 0.80 °C above the temperature in the same period of 2000-2010.Variation of average monthly temperatures are expected for the climate in which the meteorological station of Mostar is located. Values of average air temperature will be observed from the point ofclimate thermal labels according to Gracanin.

Table18:Climate thermal labels according to Gracanin

Average annual air temperature (^{0}C)	Climate thermal label
> 20	Hot climate
12-20	Warm climate
8-12	Moderatelywarm climate
4-8	Moderatelycold climate
0,5-4	Cold climate
< 0,5	Snow climate

According to these climate thermal labels,the period from 2000 to 2010 and 2011, based on average annual temperatures, have the thermal label hot climate. If these labels are applied on an average temperature then both observed vegetation seasons have thermal label hot (intense) climate. When the same thermal labels are applied to the annual monthly temperature, then 4 months (June, July.August and September) in vegetation for both observed periodshave thermal label hot (intense) climate, and the remaining three months of the growing season (April, May, and October) have thermal label of warm climates. These thermal labels confirm that the modified Mediterranean climate is characterized by intense dry summers.

Table 19:Absolutemax. andthe absolute minimum air temperature(Mostar) forboth periods

	Month													
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**max**	**min**
Abso.max. 00-10	15,5	18,1	23,4	27,6	32,5	37,1	39,6	39,3	33	27,7	22,1	15,8	**39,6**	
Abso.min. 00-10	-3,5	-2,8	0,1	4,5	9,5	11	15,5	15,6	10,5	5	0,8	-3		**-3,5**
Difference 00-10	19	20,9	23,3	23,1	23	26,1	24,1	23,7	22,5	22,7	21,3	18,8	**43,1**	
Abso.max. 2011	16,7	20,2	23,2	27,9	30,6	36,6	39,6	40,4	36,7	30	20,3	16,2	**40,4**	
Abso.min. 2011	-1,6	-0,2	-1,6	2,8	7,8	14,9	14	15,9	14,1	2,8	1	0		**-1,6**
Difference 2011	18,3	20,4	24,8	25,1	22,8	21,7	25,6	24,5	22,6	27,2	19,3	16,2	**42**	

The average annual temperature variation observed for a ten-year period from 2000 -2010 at the meteorological station Mostar is 43.10 °C. Annual variation of temperature on the same meteorological station for the year 2011 is 42 °C.

4.3.2. Amount of rainfall

A modified Mediterranean climate is characterized by favourable annual sum of precipitation from long-term averages of 1600 mm. Monthly distribution of precipitation is unfavourable from the viewpoint of agricultural production. Typically four months of vegetation are with high temperatures and inadequate rainfall for agricultural production.

Table 20: Monthly, annual and vegetationamounts ofrainfall(mm) forthe period 2000,2010 and 2011.(Mostar)

	Month												Average	
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**year**	**veg.**
2000 -10	171,8	135,9	136	108,4	84,7	75,1	41,8	63,5	143,1	146,7	184,9	199,2	1491	663,3
2011	52,2	41,3	144,5	31,5	77,1	30,6	136,1	20,8	35,5	64,9	67,7	170,3	872,5	396,5

Variations in average monthly rainfall for the ten-year period from 2000 – 2010 ranged from a minimum of 41.8 mm rainfall in July, up to a maximum of 199.2 mm of rainfall in December. The observed 2011 is atypical from the standpoint of the amount and distribution of rainfall. Untypical features are reflected in the low rainfall in I, II, IV and XI month, as well as an extremely large amount of rainfall in July. The annual variations in rainfall are ranging from least in the VIII month from 20.8 mm to the maximum in December of 170.3 mm.

Table21: Rain factors according to Gracanin for the period 2000-2010 and 2011 (Mostar)

Month	KFm 2000-2010	Climate according to Gracanin		KFm 2011	Climate according to Gracanin
I	31,24	Perhumid		9	humid
II	19,99	Perhumid		5,3	semihumid
III	13,2	Humid		14,5	perhumid
IV	7,37	Humid		2	arid
V	5,76	Semiarid		3,9	semiarid
VI	3,17	Arid		1,2	perarid
VII	1,58	Perarid		5,5	semihumid
VIII	2,43	arid		0,8	Perarid
IX	7,8	Humid		1,4	perarid
X	9,28	Humid		4,3	semiarid
XI	17,28	Perhumid		6,6	Semihumid
XII	29,73	Perhumid		21,8	perhumid

Rainy factor according to Gracanin shows that the average monthly rainfall in ten years (2000-2010) is typical of the climate in this area, with rainy and hot summers and little rainfall. The observed 2011 is atypical, with little rainfall in the rainy period it was extremely dry year. Although in VII month fell 136.1 mm of rain it was poorly usable for agricultural production because one part is lost by evaporation, and one part quickly strained intothe deeper layers through the cracks from the drought which occurredin the previous month.

4.4. Evapotranspiration of crops grown in Herzegovina

In the production of crops the basic factor is agricultural land as a natural body which carries out all life processes of crop plants. Good soil is a fundamental requirement for good production in agriculture. Land and water are inseparable and are factors of plant, animal and human existence. Water is constantly present in the soil or on the surface. The water content in the soil is variable depending on the weather and water consumption by plants. Often the water in the soil is excessive so that adversely affects the soil and plant. The other extreme is that the water in the soil is not enough for normal growth and development of cultivated plants which reflects negatively on its crops.Agricultural lands that do not have enough water for cultivation of agricultural crops throughout the growing season or only during certain times of growth and development, water isartificially added. All measures and works that deliberately and artificially increases the water content in the soil with the purpose of growing crops is called irrigation.

Water has a very important role in the life of the plant and the processes in the soil. Plants need a certain amount of water for its life processes throughout the entire growing season. Vegetableneeds for water depends on the phases of vegetation growth and development as well as climate and water conditions of the location. The content of available water in the soil is very variable. In Herzegovina,in our conditions of production and in most crops, the water content in the soil is often contrary to the needs of the plants so during the greatest demands for water, inflow into the ground is smallest.

A cultivated plant adopts water for their basic needs mainly from the soil though the root system (to a lesser extent through the leaves).Together with water it receives from the soil, dissolved plant nutrients which means that the plant at the same time "drinks and eats."The greatest amount of water the plant consumes is used in the process of transpiration and building organic matter through photosynthesis. The state of humidity and water content in the surface layer of soil is important from one, and up to two, meters deep. Water in the soil mainly comes from rainfall or irrigation and only a small part from the groundwater.

Given the great importance of water as the main biological factor to achieve the full potential of agricultural crops it is necessary in the production practice to manage water in the soil and maintain favourable water regime of top soil.

Knowing acrop's need for water during the growing period is essential data for the implementation of irrigation, it is necessary to determine it when planning and preparing for irrigation,meaning the choice of production orientation in terms of irrigation.The specific needs of individual cultures for water can be determined experimentally or with calculating methods.

Experimental methods for determining the needs of agricultural crops for water include long-term, multi-year, exact experiments that are carried out mainly in scientific research institutions.The results and findings of the experimental method are used to create the analytical methods (models) in the form of computer programs that are accessible to experts and manufacturers who are engaged in irrigation.

One of the most commonly used models to determine the water needs of crops is a computer model "CROPWAT" which was recommended by experts of the FAO (Smith, 1992). To calculate needs using this model the following data is required:

1. Characteristics of the area (latitude, longitude and altitude)
2. Crops that will be irrigated
3. Climatic indicators:
   - Annual monthly air temperature ^{0}C,
   - wind speed m / s,
   - humidity%
   - insolation and
   - amount of rainfall in mm.

Calculation method leads to the water needs of crops by value of "reference evapotranspiration" (ETo) and the coefficient of a particular culture "Kc" according to the following formula:

$$\boxed{\mathbf{ETc = Kc \times ETo}}$$

Potentialevapotranspiration (ETc) – represents the maximum amount of water, depending on the properties of the atmosphere and the available energy that can be released into the atmosphere from a specific area, fully covered with selected vegetation and well supplied with water. Potential evapotranspiration also reflects the amount of water required for the smooth development of the plant.

Reference evapotranspiration (ETo) – the amount of water, which depending on the properties of the atmosphere and the energy available in the atmosphere can occur in an area that is overgrown with grass SOD and is well supplied with water. To avoid problems in defining common parameters for all of evaporation and plant development phase, the notion of reference evaporation is defined.

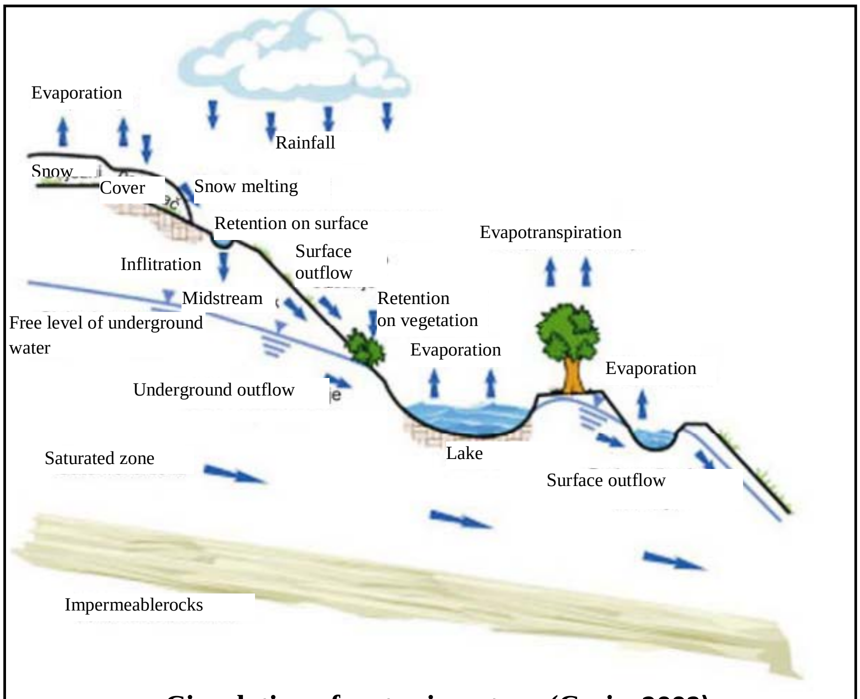
Evapotranspiration rate of different plants with plant coefficient (Kc) is associated with the evapotranspiration rate of the reference surface. The default reference area (defined by the FAO) is actively growing grass, which completely covers the ground sufficiently supplied with water, with the height of 0:12 m, the surface resistance of 70 s / m, and the albedo is 0.23. The value of the reference evapotranspiration (ETo) can be with a plant coefficient (Kc), used to calculate the water needs of certain plants.

Plant ratio(Kc) - Coefficient of plants which tells us the reference evapotranspiration for the correction of the selected plants. The plant coefficient for the individual plants at each stage of development is different. It depends on the type of plant, stage of development, and climate in a particular geographic area.

The bulk of the required amounts of water for crops in open fields in our climatic conditions during the growing season are coming from rainfall. The difference between the total water needs of crops and the inflow of water precipitation (effective or useful for the plant) makes a water deficit, which should be compensate by irrigation. The deficit of water in a given area can be calculated with following relationship:

$$\boxed{\mathbf{Dv = ETo - Oef}}$$

where Dv is deficit or lack of water, ETo Reference evapotranspiration(mm) and Oef effective rainfall (mm).



Circulation of water in nature (Ceric, 2003)

Figure47:Circulation of water in nature (Ceric, 2003)

4.4.1. Calculation of reference evapotranspiration

Irrigation systems are being designed and carried out with the aim of compensating for the lack of water needed for optimal cultivation of agricultural crops caused by lack of rainfall and / or water storage in the soil. The requirements of agricultural crops for water, or so-called irrigation requirement (Nn), is an important parameter for the design of irrigation systems.Insufficient orimproper input parameters for the calculation of certain Nn can lead to oversizing or under-sizing of the entire irrigation system.

Plants’ needs for water are defined by the amount of water that must be satisfied,evapotranspiration loss of healthy plants, grown in a field, unlimited soil conditions, including water and nutrients, and which provides full production potential under certain environmental conditions. The effect of climatic characteristics on the plants need for water is shown through reference evapotranspiration (ETo), which represents a loss of water by evaporation (evaporation) and transpiration (water loss through stomata plants in the form of water vapour) with uniformly high and actively cultivated lawn height of 8-15 cm, which completely covers the surface and does not lack water.

Reference evapotranspiration for individual weather stations was calculated by the method of FAO Penman-Monteith, in the computer program CropWat (Romic and Vranjes, 2006; Husnjak andassoc., 2009). Input parameters needed to calculate ETo are used, like available 20-year (from 1991 to 2010) average data of average daily air temperature, relative humidity, solar radiation and wind speed from certain meteorological station.

Analysis of evapotranspiration as a process of loss of water through the plant and the soil, and rainfall as the main source of water for the plant, is the first indication of the need for irrigation. Since all the measured precipitation and are not effective, because part the precipitation is lost by surface outflow and dislocation into the deeper layers (outside the rhizosphere), and a portion is retained on the plant and evaporates directly, introduced the term effective rainfall. For the calculation of effective precipitation used USDA Soil Conservation Service was method (Smith, 1992).

Relationships and dynamics of average monthly values of evapotranspiration (ETo), rainfall (A) and effective rainfall (OEF) and annual (Vgod) and vegetation (Vveg) water balance level during the analysed period, at the weather stations are shown below (Table 22).

Table22:Elements ofwater balancebyanalyzedmeteorologicalstations(1991.-2010.)

Parameter	**Month**												**Sum**
	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**	
Bugojno													
O	55	45	55	77	66	88	68	62	89	72	95	79	852
Oef	50	42	50	68	59	76	61	56	76	64	81	69	752
ETo	16	20	43	63	93	108	121	105	66	40	24	16	715
Vgod	35	22	7	5	-34	-32	-60	-49	10	24	57	54	37
Vveg				5	-34	-32	-60	-49	10				-160
Livno													
O	97	74	85	102	79	78	48	57	104	113	172	141	1150
Oef	82	65	73	85	69	68	44	52	87	93	125	109	952
ETo	19	26	47	69	102	120	140	121	75	47	24	16	803
Vgod	63	39	27	16	-33	-52	-96	-69	12	47	101	94	149
Vveg				16	-33	-52	-96	-69	12				-222
Mostar													
O	141	117	108	123	82	71	48	65	144	156	200	201	1457
Oef	109	95	89	99	71	63	44	58	111	117	136	136	1128
ETo	40	48	71	90	130	159	192	171	111	71	45	40	1170
Vgod	69	47	18	9	-59	-96	-148	-113	0	46	91	96	-42
Vveg				9	-59	-96	-148	-113	0				-407

At the level of the annual water balance in the system of the plant - atmosphere, it can be seen that in all analysed meteorological stations ETo value was less than the sum of total and effective rainfall (Table 22).However, the annual water balance is not always a realistic indication of the need for irrigation,so comparing the effective rainfall and ETo during the growing season (between April and September)completely opposite negative results of water balance are received and also at all the analysed stations.

The biggest evapotranspiration requirements occur in July and then the difference between ETo and effective rainfall is most pronounced in the amount of -60 mm at the Bugojno area up to nearly -150 mm in the Mostar area.

The total vegetation water deficit is also most pronounced in the Mostar area (-407 mm) and the smallest in the Bugojno area (-160 mm) (Table 22).

4.4.2.The needs of agricultural crops for water

In order to determine the total water needs, or so-called irrigation requirement (Nn) of different crops it is necessary to connect the reference evapotranspiration (ETo) with evapotranspiration of certain crops (ETk) introducing the crop budget coefficient (Kc) based on the following relationship: ETk = ETo x Kc (Romic and Vranjes, 2006).

For a number of analyzedcultures, specific water consumption coefficients are determined (Kc) by developmental stages due to the previously mentioned dates of sowing / planting, vegetative and generative plant development and completion of the vegetation in these environmental conditions.

Selectedcoefficients for culture are taken from Allen and assoc. (1998).

Average needs of agricultural crops for water (Nn in average climatic conditions; Table 23) were established in the computer program CropWat (Smith, 1992), and as input parameters were used:

i) the average climatic parameters (temperature and relative humidity, sunshine and wind speed) for the 20-year (from 1991 to 2010) period and

ii) the coordinates and elevation of the individual weather stations. Also, using the same model, reduction in yield (%) for the analysis of culture in irrigated conditions are determined (Table 23).

Modeled needs of agricultural crops for water are most pronounced at the meteorological station of Mostar 210 mm (strawberry) to 300 mm (apples and tomatoes), and least at the meteorological station in Bugojno 77mm (strawberry) to 112 mm (tomato) (Table 23).Also, the reduction in yield conditions without irrigation is most pronounced in the environmental conditions of Mostar (48-55%), while in the Bugojno area the same parameter is least pronounced (approximately 20%) (Table 23).

Table 23:Averagewater needsorirrigation norm(Nn) for cropsbyanalyzedmeteorologicalstations(1991 to 2010).

Meteorologicalstations	**Crop**	**Nn mm**	**Yield reduction %**
Bugojno	Apple	97	20
	Strawberry	77	19
	Tomato	112	22
	Corn	105	20
Livno	Apple	170	35
	Strawberry	122	28
	Tomato	180	37
	Corn	170	32
Mostar	Apple	300	55
	Strawberry	210	50
	Tomato	300	55
	Corn	280	48

4.5. The effects of drought on the fruits, vegetables and table grapes in Herzegovina

Fruits and vegetables

In the area of Herzegovina during the pre-war period, thefruits that dominated were citrus fruit, of which the most important surface wasunder: peach, sweet cherry, apple, plum, and a little less planted: cherry, apricot, quince, walnuts, almonds and pomegranate.

In the northern part of the region plantations of plumsdominated, especially in Prozor-Rama, while in the southern part most abundant species of fruit is the peach.

Current fruit production is characterized by the cultivation of fruit mainly in an extensive way, and there was very little planning for planted orchards. In these orchards the old abandoned varieties were dominant, with large spaces planting and poor application of agricultural practices, especially fertilization and irrigation.In addition, if one considers that the in the area of Herzegovina during the war more than 750 hectares of orchards were destroyed, and the damage was caused mainly by burning, cutting and lack of work in the orchard, because of the war, it is clearly evident that the fruit of this area cannot give the expected results without a significant investment.

In addition to raising new orchards that would be exploited in an intense way, it is necessary to replace any part of the old dilapidated assortment, establish advisory fruit service by the state, as well as providefavourable loans for raising orchards with government assistance in returning interest on loans, as it has been already done in Tuzla and Zenica (municipality Prozor-Rama is the only one in Herzegovina, which began in 2006 to encourage the planting of modern intensive orchards). A joint venture of budget funds and funds raised from contributions on wages and unemployment benefitswould be repaid together with interest from the user of the loan, depending on the size of loan and the number of employed in the project.

Vegetables in Herzegovina occupied an important place in every household. In addition to the extremely favourable natural conditions for the production of early vegetables, for years the producersfrom this area have gained vast experience in the production of vegetables, its placement on the green market, as well as a specialized agricultural machinery for this type of work.

Vegetable production in greenhouses is the most intense form of vegetable production, and thus the yields of some crops are increased by several times (tomato and pepper 2-4 times, cucumber up to 8 times, etc.), which has multiple benefits for agricultural producers.

In the period after the war, when there was re-purchasingofwar-destroyed machinery, greenhouses were raised, which produced early vegetables for placement in the larger centres in B&H. The growth trend of the area under greenhouses should continue in the coming period, because of comparative advantages of the region in this way, even more would come to the forefront, especially with the Mediterranean climate and the gained experience.

Viticulture-table grapes

The generator of development of agriculture before the war in this region was the agro-industrial complex "HEPOK", later APRO"" Herzegovina", of which very little remains of pre-war capacity and pre-war production. Part of the property and farmland of this former giant is privatized, the second part of the equipment and the production and storage facilities were destroyed in the war and is now eroding, and part of the plantation of grapes which was saved is used by some hundred workers and from that they earn the necessary existence for themselves.

In the southern part of Herzegovina the backbone for the development of agriculture is wine production, which before the war was occupied on the area of 5,781 ha, of which the wine-growing region "Herzegovina" had 5691 ha, or 98.40%.

Some interesting data shows the relationship between the vineyards that are in private and public property in Herzegovina, as well as the relationship between wine and table grape varieties.Tentative estimates show that in Herzegovina during the war, half the pre-war areas that were under the vineyards were destroyed. It is characteristic for vineyards that are still owned by the statetohave obsolete varieties and crops that are on average more than twenty years old. This can be partly true for vineyards that are privately owned.

The future of viticulture should be one of the pillars of agricultural development, because the price of grapes is generally high, and others products for the wine processing, spirits and juices, have a high price.

In every country where the grapes are grown there are indigenous local varieties, and a certain number of varieties transferred from other countries. In B&H, the local varieties are usually Zilavka, Blatina and Plavka, and from imported are: Burgundy black, Game, Merlot, Smederevka, Italian Riesling, Seminjon, Cardinal, Queen of vineyards, etc.

It is interesting that the grapes can be grown on soils are extremely modest ("scarce land"), where a large number of crops would not have been possible to cultivate. Raising the vineyards in this modest land would achieve multiple effects and that in something to be worked on hard in the coming period.

The lack of water (drought) impacts how the basic physiological functions of each plant are developed as well as the vines. Drought affects the poor adoption of minerals from the soil and their slower upward flow from the root to the leaves. Also, drought affects the creation of nutrients through photosynthesis and their flow from leaf to fruit, stem and root. The needs of the vine for water are different in different phenological stages of growth and development, and depend on outside factors. The greatest needs of the vine for water are in the phase of intensive growth, flowering and ripening of the fruit, and least in the resting stage, at the beginning of the growing season in the bud stage and at the end of the growing season in the period of leaves falling. Some organs on the same vine have different drought resistant. The upper, younger leaves because of the concentration of cell sap have the capability of taking water from the lower, older leaves and fruit, which makes them more resistant to drought. Deep and well-developed root system allows grapevine tolerance to drought of short duration.

Table varieties are generally more abundant than wine grape varieties and therefore have the worst tolerance on drought impact. Visible signs of prolonged drought on grapevines are drying up and falling of lower, older leaves and the loss of water from the bottom of the berry cluster. The loss of water from the berries is manifested subsequently by wilting first, and then by the drying of the berries. The consequence of the lack of moisture is poor differentiation of buds and immaturity of shoots because of insufficient nutrition. In this way, the lack of moisture in one year is carried into the second year because the immature saplings during dormancyare less resistant to low temperatures, and in the next year vegetation from the undifferentiated plant buds will have a lower growth and a smaller yield in terms of quantity.

The effects of drought

Based on the currently known analysis of the impact of climate change on the region of Herzegovina it can be expected that the increase in the intensity and frequency of drought periods will be present.Most significant impacts of climate change include:

1. increase in air temperature on an annual basis but also during the growing season and at the change of seasons;
2. reduction of rainfall in the summer period of the year;
3. increase in intensity and frequency of extreme climatic phenomena;
4. effect of increasing temperatures will dictate increased desiccation;
5.since evaporation is increasing together with the increase of temperature in many areas will increase drying which will have a direct impact on agricultural activities
6. low level of rivers flows during the summer period will hampered the ability of irrigation and water supply
7. lack of water will be especially important in the summer, during the agricultural season and intensive water use, which will directly impact on the water resources problem.

As already mentioned earlier, drought in significant measures may affect fruit production. By analysing averages of rainfall in the last 10 years we can see that the water deficit occurs most frequently in June, July and August and during the growing season when the essential processes of growth and development of fruit treesoccur.Also, the lack of water during this period is accompanied by high temperatures, which further enhances this effect. During this period there is a rapid growth of the fruit, fruit preparations for the next year (the formation of generative buds), the increase in length, the completion of the formation of leaf mass, indicating that the drought in this period has a major impact on yield in the current year but also in the next.

It is therefore necessary to begin work on drafting a **plan for irrigation** for the entire Herzegovina area as a region and establishment of irrigation systems, as in the near future the problem of water shortage will be more pronounced. Also the educationof producers should begin regarding the negative impacts of drought and high temperatures on the growth and development of fruit trees.

5. ADAPTATION OF FRUITS, VEGETABLES AND TABLE GRAPES ON DROUGHT

5.1. Significance and types of adaptation to drought

5.1.1. The impact of drought on agriculture

According to the strategy of adapting to climate change and low emission development in Bosnia and Herzegovina (Radusin and assoc., 2013), the key impact of climate change on agriculture is reflected negatively in terms of reduction in yield as a result of reduced precipitation and increased evaporation rates; potentially reducing the productivity of farm animals; increased incidence of pests and diseases of agricultural crops; increased supply of food insecurity, while it positively affectsthe extended growing season for crops, greater potential for growing Mediterranean crops especially in Herzegovina. Advanced drought research (agro climatic index, rainy and dry series) will enable the development of effective strategies for adapting agriculture to climate change.

Drought is an extreme climatic event which can become the natural disaster. The intensity of drought should be assessed with regard to the consequences caused.The main cause of the drought is thedeficit of rainfall in a given area, compared with an average rainfall of the area. Drought is manifested with the appearance of a significant deficit of all aspects of water in space and time. It should be noted that the notion of a significant deficit of water is a key criterion, but also a measure of drought and it differs significantly from case to case. Distinguishing between several types of drought may help to better understand these natural phenomena (Michael and Workineh, 1991). Probably the biggest problem associated with drought is the fact that science cannot determine the reasons why they occur. Due to the impact of drought, grass and shrub cover are decreasing in size.The lack of rainfall causes stress in the development of plants.Stressis the state or changes in circumstances that deviate from the optimal conditions for the growth and development of plants and cause reactions and changes in the structural and functional processes at the level of the whole organism (Vukadinovic, 1999). The occurrence of stress is time dependent and processes that take place are the subject of ongoing volatility. Lack of water in the root zone or a lack of oxygen caused by excess water leads to a change of direction assimilates that is changing the relationship between the mass of roots and above-ground organs in favour of roots or an early flowering is set (accelerated flowering) or falling leaves. Plants that grow in soil poor with nutrients and water grow more slowly and are usually short. In that way the plants achieve a compromise, the plants are adapted to the existing conditions, because smaller habitat has a higher concentration of nutrients in the tissues and uses less water (Poljak, 2002).

Agro-economic factors such as soil moisture (substrate), air temperature and mineral nutrition can also significantly affect the water content in plants. For example, high temperatures in the summer can significantly reduce the water content, which visibly reduces turgor of the plants, and lap wilt symptoms, caused by atmospheric drought alleviation by reducing insolation and temperature. In resistant plants the accumulation of "heat-shock" proteins (HS) are shown, which play a role of functional proteins from denaturation, not only in stress due to dehydration of protoplasm, but also during its reparations. External factors that inhibit the process of root breathing cause occurrence of physiological drought, because they prevent the adoption of the necessary amounts of water (Poljak, 2002).

Heat stress in plants is closely related to the water shortage, and the symptoms are often identical, and mechanisms of adaptation in the anatomical and physiological terms are similar. Anatomical adaptations / adjustments to heat stress based on the reduction of insolation of leaves (reflective substance in the composition of the cuticle, the formation of hair, twisting the leaves, change the position of the leaf surface to the angle of incidence of sunlight) and improve the adoption of water (deeper root development). At the cellular level, high temperature increases the fluidity of cell membranes, disturbing their physiological functions (Poljak, 2002).

Given the stress factors that accompany the occurrence of stress there is a difference in:

- STRESS FACTORS–factors causing the stress or stress source.
- STRESS REACTION OR STRESS CONDITION–change occurred as the reaction on the stress factors as well as adaptation on the newly created state
- STRESS AVIODANCE–protection and regulatory mechanism of the resistance to stress through maintenance of the balance between the external environment and internal protoplasm of the cell
- TOLERANCE–ability of the cell, organs and organisms to fight the effects of stress.
- FUNTIONAL STATE –represents the dynamic reaction of the whole organism to the cause of stress.
- REACTION TO STRESS–race between the adaptationand potentially lethalprocesses that occur in protoplasm of the cell.
- STRESS DYNAMICS –represents destabilization and destructive component (distress) as contra measure or reaction to stress leading to restabilization and resistance (eustress).

According to the dynamic model of stress, the body under the influence of stress factors pass through several characteristic stages:

- ALARM PHASE -consequences of stressis thedestabilization of thestructuralprocesses(proteinsandbio membranes) andfunctional processes(biochemical processes, energy metabolism, etc.).
- PHASE OFRESTITUTION- occursas a reaction tostresswhichseeks tocounteractdisturbancesmeaning tore-establishthefunctional andstructuralfunctions ofcellsandrestoresthesynthesis ofthe protein orde novosynthesisof protectivesubstances.
- RESISTANCE PHASE-thatdue tothe continuousactionbecomes strongerandfinallycreatescertainresilience- strengthening(hardening).
- Through the improvements in stability of conditionsof growing plantsthere is anormalization of the situationdespitethe continued applicationof stress.Ifthe state ofstresscontinuesfor a long timeor if theintensity is comingto the stageEXHAUSTION PHASE – which occursduring the finalstagesof stressandtheseplantsmakes are susceptibleto stressbecause they do not have sufficientstrengthto resistand collapse ofcellsoccurs.

5.1.2. The resistance of plants to drought

The resistance of plants to drought is characteristic of plants to withstand high temperatures and lack of water. It is therefore very important that when considering this resistance to take into account the biological characteristics of the plant (root system, anatomical structure of plant organs, the pace of development, etc.). Plant resistance to drought depends on morphological and anatomical and physiological properties of the plant, i.e., their ability to adapt to conditions of water shortage (Poljak, 2002). Plants resistant to drought are those that are able to adapt to the impact in the process of ontogenesis and in such conditions to realize the normal processes of growth and development. The great importance of the resistance to drought has colloid-chemical properties of protoplasm, as follows: viscosity, elasticity, the amount of bound water and so on. Damage and death of the plant affected by the drought are different. Water deficiency impairs the synthetic ability of the plant, the hydrolysis of proteins and altering of the colloidal property of protoplasm occurs. Lack of water causes changes in the exchange of carbohydrates and protein, changing the activity of oxidative enzymes of breathing.Lack of water affects particularly harmfully to plants or to the physiological and biochemical processes that take place in them.

5.1.3. Morphological and physiological resistance of plants to drought

Plant species adapted to long-term drought can be divided into:

- SUCCULENTS - plant speciesthatare characterized bya thickcuticle, a small number ofstomatathat arethroughout the most of thedayclosed.
- XEROPHYTES WITH THINLEAVEShavemostlyopenstomata, long andwell-developedroot system.
- XEROPHYTES WITH SOLID AND THICK LEAVESare characterized byhard skin tissue,welldevelopedvascular tissue, which canendurelongandwithering.

Most cultivated species belonging to mesophytes can sustain current drought without major adverse effects on yield. Mesophytes are widespread in moderately moist soils and aerated soils. Resistance to drought in mesophyte is characterized by the development of shorter internodes, forming a relatively thick cell walls and plasmalemma, elastic and viscous protoplasm, and small cell vacuoles (Dubravec and Regula, 1995).

The mechanisms of adaptation or drought resistance in plants are:

- the creation of hard skin layer of waxy coatings and fibrous tissue-insulating material,
- building silicon in the cell wall,
- creation of cuticle and corky surface,
- creating peripheral sapwood.

The resistance of plants to drought is reflected in the ability to neutralize the adverse changes in metabolism, i.e. in maintaining high synthetic ability, and this resistance is of particular importance for development of the root system, anatomical structure of plant tissue and stage of development.High content of osmotically active substances in the cells, in particular K +, and other ions, provides better hydration and greater retention of water in plants via the regulation of membrane transport mechanism and work of stomata.An important role in resistance to drought and low temperature is the hormone of acid (ABA), whose main role is to dissolveexcess of fruits (abscission) and generally has the function of hormone inhibitors. With the lack of water or dehydration of plant tissues, the synthesis of abscisic acid is growing in leaves, resulting in stomata closure and reduction of transpiration, reduced shoot growth (but not the root), induced accumulation of reserve protein in the seed, and a mature seed entering the dormant state (Pevalek-Kozlina, 2003).

For drought stress, we can say that it is an inevitable problem (but only when the farmer does not take enough care of their plants) that occurs in economies around the world, from which many farmers dread, fearing to lose their crops. When they run out of yield theycannot hopefor revenue. The factors that cause drought stress are high temperatures, too strong solar illumination intensity and the lack of water in the soil. To alleviate this problem at least to some extent there is a need to be alert and conduct preventive protection of crops, to provide water supply when it is most needed. This is the only way we can hope for profit, because, the plant if protected from adverse external influences, gives the best yield and best quality of fruits.

5.1.4. Measures to overcome stress conditions in plants

Resistance to stress involves the reduction of stress (avoidance), and tolerance to stress. Plants that avoid stress generally complete their life cycle during the wet season, before a drought occurs, while tolerant plants have the ability to function with dehydrated tissues (Pevalek-Kozlina, 2003). The genotypes of different species of plants are characterized by the phenomenon of early maturity (i.e. the mechanism used to avoid stress) to complete their life cycle before the onset of a period of intense drought, with achieved increased metabolic activity and rapid growth (McKay andassoc., 2003).There are also plants that delay drying out, or have the ability of tissues to retain moisture, such as succulents. Constant exposure of plants to stress, therefore, can isolate genotypes that are resistant to this type of stress that have been adapted to the habitat conditions in which it lives. In humid locations water losses can be easily compensatedby receiving water from the soil, while in arid areas or during longer dry periods it may cause water shortage which has a very negative impact on the growth and development of plants (Keresa and assoc., 2008).In order to reduce water loss through stomata, substances that reduce transpiration are applied, i.e. various antiperspirants.

According to the mode of action, antiperspirants can be divided into three groups:

• metabolic antiperspirants,
• antiperspirants that create a waterproof film (membrane)
• antiperspirants that reflect light.

Metabolic antiperspirants partially close stomata, and reduce water loss, but can lead to a reduction of photosynthesis because of slower CO2 adoption so they are applied where water conservation is more important than the growth of plants (Vukadinovic, 1999).

Loss of water can be prevented by the substances that create a very thin membrane (film) and in doing so close stomata. Such substances are emulsions that do not leak (silicone and polyvinyl chloride), and last for about a month after application. The reflective material is used to reduce the absorption of light.These substances allow CO2 and oxygen to pass, but due to the rejection of lightit can reduce photosynthesis, so generally it is applied only on plants with smaller requirements for light. ABA could be applied as antiperspirants in plants in arid areas with prolonged drought. This hormone could be applied before the onset of drought or in its early stages which would allow the plant to maintain its water balance during a long term drought. However, this only applies to C4-plants while the C3-plants have a negative correlation between the accumulation of ABA and drought resistance (Dubravec and Regula, 1995). Regarding the ABA as antiperspirants,further testing are required. Antiperspirants,for now,are little used in agriculture because their use can have adverse consequences. Thus the closure of stomata can reduce transpiration of 60-80%, but at the same time increases the temperature of the plant that can reach critical values. Due to the lack of CO2 significantly the intensity of photosynthesis is reduced. Since there is no transpiration flow, the influx of nutrients is reduced - especially those that move primarily through the xylem such as calcium and boron. Antiperspirants, for now, still solve short-term problems related to the drought and are not in wide practice as a regular measure.

In the following years the Mediterranean will be devastatedwith even fiercer drought, and the main reason is agriculture.Irrigated area in the Mediterranean region since 1960 till today has doubled according to sources of WWF. Irrigation systems now make up the largest consumer of water, they themselves "drink" and spend as much as 65 percent of total water consumption, according to a report in the Mediterranean World Wide Fund for Nature. The processes of drying out of the soil can occur in places with high or low rainfall. The decline of the biological potential of the area can be considered one of the consequences of land drainage. Several major human activities affect the condition of the soil, wrong tillage, poor irrigation, excessive deforestation and farming. Reclamation areas can contribute to changing the albedo of the earth's surface, and these changes can have an impact on the facilities and the regional precipitation processes. During periods of normal rainfall negative effects of human activity are not clearly observed, but at the arrival of the dry season they become clearly visible (Michael and Workineh, 1991). Drought is one of the most important abiotic stresses, and losses in crop production due to drought, on a worldwide basis, reach a value of $ 10 billion per year (Guha-Sapir and assoc., 2004).

Intensive fruit production, viticulture and horticulture is dependent on climatic conditions, therefore, the defensefrom ice becomes imperative in modern production. Increasingly, orchard and vineyard production systems require a set of structures to defend against hail as the only measure of unforeseen weather conditions. Drought periods in the early spring periods have increased, which coincides with the sowing and planting of most vegetable crops in Herzegovina. In addition to selecting very early cultivars or varieties resistant to drought, it is necessary to systematically invest in the construction of reservoirs, the acquisition of irrigation systems, drilling or digging wells for irrigation and construction of the necessary infrastructure for irrigation to larger production systems in both orchards and in vegetable growing might preserve and make investment economically worthwhile.

5.2. The impact of drought on crops in the examined region

5.2.1. The impact of drought on the production of fruit crops

Last season we have witnessed increasingly frequent dry periods during the course of intensive growth and development of fruits in orchards. Not only that it is a drought periods, but the temperatures are extremely high for an extended period, causing the plant to experience extremely stressful conditions through which it must pass, and it greatly reduces the quality.

Moisture deficit in the beginning of the growing season negatively affects the overall plant growth; poor growth of leaves, flowering is weaker because declining flower buds. Water deficit in the second part of the growing season affects early (forced) fruit ripening and falling, poor formation of flower embryo, aging and defoliation, which disrupts photosynthesis and less accumulation of nutrients and poor wintering for fruits and damages in a larger scale.

In the dry season the leaves of fruit trees can take away the water from the fruit due to the difference in osmotic pressure. Thus the fruits remain smaller, poorer in quality. Alteredare the physiological and biochemical processes in plants, forming compounds that deteriorate the quality of the fruit.

The study of the water regime of plants in fruit crops is significantly more complex than in other plant species (vegetables and field crops), and it is mainly related to the following:

- there are more fruit species with a range of its specificity;
- within one species there are a large number of varieties, from very early to very late;
- orchards are grown in all soil types (skeletal, sandy, light, medium-heavy to heavy, clay, weaker to stronger water regime ...);
- orchards are grown in different climatic conditions, higher or lower altitudes;
- difference between the old plantation and young, full growth of young, etc.;
- difference between classical or dense planting, rich or less rich base, ...

In general we can determine the water needs of a variety of different phenological stages of growth and development, and comply with evapotranspirationenvironmental requirements are conditioned by complex factors, biotic and abiotic nature.

According to the water needs, growth and development, the need for water of fruit crops can be divided into several periods.

In early spring flower buds swell and continue to increase which takes place in the cold season. At the same time the root system develops rapidly with the maximum increase in soil that is in this part of the year with high water content and good breathability what causes minimal mechanical resistance.

Flowering and fertilization also takes place during low evapotranspiration of environmentrequirements, when transpiration is low and so are the needs for irrigation minimal or non-existent.

With plants entering in the intensive phase of vegetative growth, shoot growth, the formation of leaves and initial development of fruits, the need for irrigation is increasing, if at that time there is no sufficient amount of natural rainfall.

Figure 48(a,b):Consequences ofdrought onfigsfruits(Source: Dzubur, A.)

Following the decline and thinning of fruits, intense stage of growth occurs as well as an increase in overhead and underground vegetative organs to the stage of maturation when the water needs are significantly higher. All these processes are carried out intensively at low air temperatures and the optimum water content in the soil.

A sufficient amount of water in the soil is important not only because of the intense increase in yield and the creation of satisfactory quality but also due to the formation of flower embryos for next year.After harvesting the fruit, vegetative plant growth can take place until late autumn and the onset of first frosts.

Last season (2013), in this sense was a very extreme season, with over 60 days of high temperatures, as well as night temperatures, and there was a lot of damage to the fruits from burns, with damages of over 35% in certain varieties, particularly in orchards without safety nets, and fruit growers also had big problems with the colouring of fruits.

Significant damage from burns were recorded in orchards without installed safety nets, especially on the western slopes, with longer and more intense insolation and less lush trees.

Figure 49(a,b):Burnsonapple fruits

To better understand the impact of drought on the production of fruits, it is necessary to know its requirements according to the amount and distribution of precipitation in different stages of development and growth of the fruit. Because of this fact, fruit trees will respond differently to the lack of water at different stages of development. In dry conditions, the level of photosynthesis can be reduced by 20%, and in the extreme, much more, so there is a reduction in the tree production, growth and fruit development.

Figure 50: Consequences of thedrought onfruit ofthepomegranate(Source: Dzubur, A.)

Flower buds with most fruit species are primarily initiated during the first 50 days after flowering, so the early dry season, especially in combination with the heavy fruit load, can result in poor initiation of flower buds. Fruit growth during the first 50 days of flowering is mainly caused by the division of cells in the fruit, and the fruit grows at the expense of expansion of these cells. Early drought is most harmful for the growth of the fruit, because in this period, cell division occurs in the fruit, and fruit size is directly correlated with the number of cells.

Drought stress during mid-season will reduce the increase of saplings. The main tree and root system growth takes place in late summer and autumn, so that the drought in this period significantly reduces the increase in the trunk and roots, which is very important for young trees where cultivation form is set and which should have good growth.

Figure 51(a,b):Consequences of thedrought onfruits oftheolive tree(Source: Aliman, J.; Dzubur, A.)

A significant portion which defines the quality of fruits is fruit coloration, which gives them a market value.In stressful conditions caused by drought, the colouring and fruit is limited. So, everything slows down photosynthesis, and can result in lack of color. Anthocyanins, flavonoids, carotenoids are the main chemical substances that are involved in building colours. Anthocyanins are the most important substance in the formation of red color, which is found in the skin, and it may increase the amount during the ripening of certain varieties up to 5 fold. The biochemical pathway leading to the production of anthocyaninsis highly dependent on the availability of carbohydrates and enzymes, so that the environmental conditions in conjunction with physiological factors when it comes to producing of anthocyanins. Low temperatures at nightmake better colouring, because they reduce the loss of carbohydrates in the skin of the fruit, reducing respiration, so more carbohydrates remains for the synthesis of anthocyanins.It is known that the decline of the fruit before harvesting is conditioned by environmental conditions.Storage capacity of fruits directlydepends on the content of starch in the fruit. The starch in the fruit accumulates over a period of growth of the fruit, and then at the beginning of maturation converts into sugars.

The stored starch in the fruit is the source of energy for fruit tissue in storage, so the fruits harvested with a small reserve of starch cannot be stored for a long time, and they become softener before it is expected. In extremely hot years, conversion of starch into sugars is extremely rapid. Also physiological disorders such as bitter spot vitreousness and bursting fruit can be present in drought conditions.

5.2.2. Impact of droughton the production of vegetable crops

In recent years, weather fluctuations in the production of vegetables seem quite unstable. Although a broader geographic area of Herzegovina has great potential of water streams and water reservoirs, however, a major problem in the production is a lack of water during the growing period.Water shortage and drought destroys effort and often causes a loss of motivation by the producers. Plants delayed in growth, become vein, yellow, and die if such situation continues for a longer period.

Figure 52: Harmful effects ofdroughton thetomatoes plant

Figure 53(a,b):sunburnandpeakrotintomatofruits

Some varieties and hybrids of vegetables have different relative resistance to the negative effects of high temperatures and lack of water. The resistance of plants to specified environmental parameters is related to biological characteristics and metabolism of plants. Varieties that are not resistant to the high temperatures in such conditions reduce breathing, and also the activity of the enzyme peroxidase. Under conditions of high temperature, plant metabolism is going in the direction of hydrolysis, so the non-resistantvarieties increase the content of toxic substances such as ammonia.

Due to reduced photosynthetic activity in potato, the accumulation of carbohydrates in the tubers is prevented and tubers are of less weight.

Figure 54(a,b):Flatsurface ofthetuber - indicator of drought
(Source: Josipovic, M.and assoc., 2009)

Irrigation is defined as supplemental measures in agricultural production, yet modern vegetable production cannot take place without the timely supply of sufficient quantities of plants easily accessible water. It should be kept in mind that vegetables poorly exploited winter water reserves in the soil, and for the most part vegetables are supplied with water from rainfall. The vegetation period of vegetables in the Herzegovinian climate runs from March to October in the southern parts. During the most intense period of the growing season, when there is the highest water consumption for processes of transpiration and evaporation, the Herzegovina region has the characteristics of arid, semiarid and peraridne climate, and natural precipitation is not sufficient for continued growth. The period of the year with a label of semi-humid climate, which is often in May and September, because of irregular distribution of rainfall, the plantscannot meet all the needs for water naturally.

Great vegetable needs for water are resulting from the basic morphological and biological characteristics. The water content of the vegetable is 85-97% of the total weight. Vegetable crops have usually stronger production of overhead organic mass in relation to the root. The most active rooting zone is situated mostly in the shallow upper layer of soil to a depth of 10-30 cm, where normally the minimum of water is held. A harmful effect of high temperatures and drought conditions are particularly pronounced in perennial vegetables that have shallow roots and less suction power. These adverse environmental factors are more tolerant for vegetables like watermelon and cantaloupe, which have developed stronger roots.

Production problems result from the decrease of the relatively unfavourable and the favourable growth conditions, such as prolonged stress caused by a lack of moisture or high temperature, followed by an excessively irrigation or intense rainfall. In such conditions (moisture stress) radial and concentric cracking of tomatoes fruits occur. The potato tubers cracks, resulting in cracking and abrasion appearance on the surface of the tuber. Cracks that occur on the surfaces of potato tubers heal, but visible traces remain. The cracks usually occur in potato apical and can be extended in length. They vary in severity from superficial abrasions to a tear throughouttubers, depending on the growth phase in which the tubers is located.

Figure 55(a,b):Cracking oftomato fruits - indicatorof moisturestress

Figure 56(a,b) Cracks inthe potatotuber - indicatorof moisturestress
(Source: Filipovic, A.)

Specificity of vegetable crops is an increased cell tissue for gas exchange (stomata) through which intense transpiration takes place.Stomata are open during the day and night in conditions of favourable soil moisture, while in unfavourable soil moisture during the day stomata are half-closed and open at night, which affects the increased water loss. Unlike vegetables, for other crops that are more resistant to drought conditions in unfavourable soil moisture, the stomata are closed.

The requirements for water in vegetable species are shown through a transpiration coefficient whose values vary within wide limits.To build one unit of dry matter in vegetables 500-800 units of water is needed, which is much higher than other field crops. Water consumption depends on cultivation varieties, environmental conditions and agricultural management practices (fertilization, plant density, irrigation), which means that the values of the transpiration coefficient is variable. Unbalanced fertilization with a greater amount of nitrogen leads to an increasing transpiration coefficient. Nitrogen promotes stronger development of leaves, while the root remains in the surface layer of the soil and cannot adopt water from deeper layers. Plants that are planted closer together for optimal growth have higher consumption of water and transpiration coefficient.

For the cultivation of vegetables, it is important to know the critical periods of need for water. In these periods, the plant has the greatest need for water and is most sensitive to its absence. With most types of vegetables,the critical period is in the phase of intensive growth, from the flowering stage to the formation of the fruit. Also, it is important that the soil is supplied with sufficient amounts of water in the initial stages of root growth to encourage its development, which will enable the adoption of water from deeper soil layers in the later stages of growth, which often take place in drought conditions.

To regulate the water regime of the soil,it is necessary to know the types and categories of water in the soil and in the plant. Various forms of water in the plant (free, and metabolic) regulate certain physiological processes. The largest part of the available water is transpiration water, which is the regulator of heat in the plant and allows for the adoption and transport of materials from the roots to the aerial organs. Metabolic water is less mobile and is related to protoplasm and various organic compounds. Free water is determined by the intensity of physiological processes in the plant, while the bound water is determined by the resistance of plants to adverse environmental conditions (drought). The process of photosynthesis consumes only 1% of the water that the plant contains. However, the loss of water leads to disorders of physiological and biochemical processes that cause drying of protoplasm in which capacity for photosynthesis is reduced. Reduction of assimilation does not reimburse dissimilatory loss, which leads to a reduced growth of plant mass. If the amount of water is reduced by 30% under normal conditions, photosynthesis is noticeably weak, and if the amount of water is reduced by 60%, photosynthesis ceases (Penzar, I., 1989).

The ground water is in two forms. Unlike fixed-bound water, free or moving water is accessible to plants. Capillary form of free water is not subject to gravity, it is available for adoption by plants because in the ground it is held by weak forces and represents the most important part of water for agricultural practices. It is the amount of capillary water in the soil that indicates a field water capacity (PVK) and irrigation practices defined as the upper limit of the optimum moisture content. Condition of soil moisture at field water capacity is perfect for growing vegetable crops. The beginning of irrigation is determined based on the lower limit of the optimum soil moisture, which is marked as lento capillary humidity (LKV). Since this water is tied by strong force,plants have difficulties to adopt it and begin to experience water stress.

A typical symptom of a lack of water in the soil for apepperplant is the loss of turgor of leaves in the warmest part of the day. The plant has difficulties to recover from that initial water stress, and the irrigation should begin before the onset of symptoms. Similar symptoms occur with tomatoes, watermelon, cantaloupe and legumes when flowering occurs during dry season, which leads to shedding of flower buds, flowers and fruit set. The remaining few fruits are sparse and stunted, which leads to significant loss of yield. If the period of drought continues, the water content in the soil is still down and the plant has not been able to adopt it. These are then called humidity wilting plants (VV) at which physiological processes cease and it leads to massive crop failures, which occurs in extremely dry years.

In addition to the optimal water regime of the soil for normal physiological functions,the optimum humidity is important.Vegetable crops vary considerably according to the humidity needs. The plants with the highest requirements for humidity are cucumber (90-95%), cabbage (85-90%), lettuce (80-90%), moderate requires have beans and potato (75-80%), while,peppers (50-70%), tomato (50-60%) and watermelon (40-65%) are sensitive to the excess humidity.

5.2.3. The impact of drought on the production of table grapes

Viticulture is the branch of agriculture which production is defined in a state act and is called zoningof grape-growing in B&H.All wine production in B&H is conducted in two vineyards Mostar and Listica which belongs to the rayon of Herzegovina. Any prerequisites for growing vines in a given area are determined by climatic conditions. Although vine farming has high demands for climate, this climate change still has a negative impact on this branch of agriculture.

Lack of rainfall in June, July and August are forcing producers to compensate for this with irrigation,which increases the cost of production. Construction of irrigation systems is a complex project that farmers themselves are not able to realize, neither technically, financiallynorin legislative (Water Act) terms. Lack of rainfall, with more frequent occurrence of high temperature, longer duration,low relative humidity and winds, are leading to droughts. If producers do not have access to irrigation, then the yield is inferior in quantity and in quality with the increased cost of production, which leads to non-profitability and the uncertainty of production.

All this leads to a more difficult decision to go into the vineyard production if there is no irrigation. Excess water in the rainy period leads to acidification of the soil, washing out nutrients into the deeper layers inaccessible to roots, which ultimately seeks greater investment in repairing the pH of the soil and increased intake of nutrients.All this is a larger and more prominent issue in the production of table rather than in the production of wine grapes.

5.3. Proposal of measures for adaptation of fruits and vegetables and vines on drought

Fruit

Adapting to climate change and drought is currently on a poor level of agricultural production, as well as in fruit production.

Potential adaptation measures to drought in fruit production are:

-raising awareness among farmers about climate change and its impact on agricultural production, or fruit production;

-selection of varieties and fruit varieties that can grow and develop in certain micro-and macro-climaticconditions;

-development of models that provide information about the distribution of planting suitable varieties of fruit trees

-size of plantation

-choice of location (position / exposure) for raising crops

-weed control

-adequately maintaining land in orchards

-appropriate ways to use organic fertilizers and mineral fertilizers, especially the introduction ofsmaller quantities of fertilizer to the soil in proper time

-improvement and development of techniques to protect against the hail

-construction of reservoirs and basins to collect water: rain and other precipitation, and construction of networks and irrigation systems

-building modern farming systems "at the reach of hand"

-improving weather monitoring and forecast weather conditions

-improving forecasts and early warning on the occurrence of droughts or floods, frost, etc.

Vegetables

The influence of climatic conditions in vegetable production can be somewhat modified by properly executed agro-technical measures such as the choice of species and varieties of seeds and planting materials, proper and timely planting, processing and soil fertilization, weed control, cover of land and crop variety of materials, application of conditioner, the application of modern technological processes in production in protected areas, raising windbreaker belts as well as different methods of selection and breeding of plants. Applying these measures affect the properties of the soil, the climate and the elements of cultivated plants and thus alleviates the effects of drought. These are indirect measures to combat drought which aims to collect as much water in the soil and reduce its loss by evaporation and runoff. The proper selection of varieties to microclimate cultivation areas is of great importance to obtain high and stable yields. Some cultivars and varieties of vegetables differ in a number of morphological, biological and economic characteristics including the length of the growing season and different responses to temperature. Based on the biological characteristics and adaptability to the conditions of the environment in which to grow it is necessary to always choose the types and varieties that are more resistant to adverse conditions (drought or low temperatures). For the intensive production of vegetables it is recommended to use hybrid varieties with high yield potential that have already been through the selection procedures and are more or less adapted to specific ecological and environmental conditions.

The selection of varieties of a certain length of vegetation should be adjusted to the time of production. The length of the growing season depends on growth conditions as well as the weather conditions of the production area, and thus can be variable. To minimize the problem of drought, it is important to adjust the terms of sowing (planting) to the vegetation period of cultivated species coinciding with the cycle of rainfall in the growing area. In arid regions growing early varieties of shorter growth seasons as early sowing in the spring it is possible to take advantage of spring soil moisture and avoid the negative effects of dry periods.

A direct measure to combat drought is irrigation approach, which emphasizes the importance of rational use of water within the existing and future planned irrigation system.

Table 24 shows a list of varieties for commercial production of certain types of vegetables in Herzegovina. It is important to emphasize that the high yields and quality can be achieved only by applying the above, all preventive and agricultural practices with an emphasis on the importance of the primary factors - application of irrigation.

Table24:Assortment ofvegetablesfor commercialvegetable productionin Herzegovina

Vegetable type	**Hybrid (variety)**	**Some characteristics of the hybrid (variety)** Growing season/early maturity/growth type/typefruit/flowertype/specificity
Tomato	Belle F1	spring-summer-fall / early/ high
	Buran F1	spring-summer-fall / very early/ high
	Amaneta F1	all year/veryearly/ high/excellentfertilizationin extremetemperature conditions
	Rally F1	winter-spring / veryearly/ high/goodfertilizationinpoor conditions
	Monroe F1	spring-summer-fall / early/ high
	Lustro F1	spring-summer-fall / early/ high
	Minaret F1	spring-summer-fall / early/ semi high
	Jaguar F1	spring-summer/ very early/ high
	Melodia F1	spring-summer/ very early/ high
	Optima F1	spring-summer/semi early/ high
	Hector F1	spring-summer/ semi early / low/ open cultivation
	Baghera F1	spring-summer/ early/ low/ open cultivation
Paprika	Vedrana F1	spring-summer-fall/very early/type of fruit bell, most adaptable hybrid
	Istra F1	spring-summer-fall / very early/ type of fruit bell
	Blondy F1	spring-summer-fall / very early/ type of fruit bell, there is noappearance of symptoms of peakrotdueto lack ofCa
	Idil F1	spring-summer-fall /mid early/ type of fruit bell
	Slonovo uho	summer-fall /mid late/type of fruit horn paprika,open space cultivation
Cucumber	Darina F1	spring-summer/ very early/ salad cucumber/ mostly female flowers
	Jazzer F1	spring-summer-fall / very early/ salad cucumber/ mostly female flowers
	Dinnero F1	spring-summer-fall / early/ salad cucumber/female flowers
	Ekron F1	spring-summer-fall-winter / very early/ salad cucumber/female flowers
	Edona F1	spring-summer-fall / early/ salad cucumber
Cantaloupe	Centro F1	very early/ type of hybrid: meshwith strongribs
	Early Dawn F1	very early/ type of hybrid: meshwith strongribs/ cultivation in open in low tunnels and protected spaces
	Lillo F1	very early/ type of hybrid: meshwith strongribs

Table 24: continued

Vegetable type	**Hybrid (variety)**	**Some characteristics of the hybrid (variety)** Growing season/early maturity/growth type/typefruit/flowertype/specificity
Watermelon	Fantasy F1	mid early/type: Crimson Sweet/greatfor growingoutdoorsin lowtunnelsfor oneharvest of the fruits.
	Farao F1	mid early / type: Crimson Sweet/because of the strongroots and growth rate, plantshasincreasedresistance tounfavorable conditions of cultivation.
	Emperor F1	mid early / type: Crimson Sweet/ good yieldsachievedunder various conditionsof production
Salad	Flavy	cultivationinshort-dayconditionsin protectedareas/green crystal
	Funway	latefall-winter-late spring/ in protectedareas/ light yellowcrystal
	Angie	cultivationin protectedareas/lightyellow-green semi crystal
	Noisette	cultivationin the warmerperiod of the year / saladcrystal/resistant toearlyflowering andtheedgeblight
	Vanity	spring-summer-fall on open space/ saladcrystal/ resistant toedgeblightin condition s of drought and high temperatures
	Tatiana	spring-fall / salad maslenka
	Pronto	cultivationin the warmerpart of the year/saladmaslenka/very resistant toearlyflowering
	Indiana	salad maslenka/good resultsin low light conditions
	Daguan	outdoorproductionthroughout the year/salad maslenka
Cabbage	Pandion F1	very early/recommendationsfor growingin greenhouses
	Parel F1	very early/ cultivation in open and greenhouses
	Farao F1	early / cultivation in open / heads resistant to cracking
	Sir F1	productionthroughout the year/ heads resistant to cracking
	Bravo F1	mid late forfall consumption in fresh state and for pickling/ length ofvegetation90-95 days
	Saratoga F1	length ofvegetation is around146 days
Kale	Premius F1	very early/ length ofvegetation is around 60-65 days.
	Capriccio F1	length ofvegetation75-80 days/primarily for harvest inlatesummer and begging offall
	Concerto F1	fall/ length ofvegetation95-100days
	Rigoleto F1	fall / length ofvegetation135-140 days
	Wirosa F1	latefall-winter/ length ofvegetation140 days

Grapevine

Irrigation is a measure which compensates for the lack of water at critical stages of growth and development of the vine. If there is no possibility for irrigation, negative effects of the lack of water in the vineyard can be reduced by the following measures: a selection of varieties and rootstocks when planting vineyards, the appropriate form of cultivation, fertilization, timely weed control, frequent surface tillage, green pruning, treating the leaves treatedwith foliar fertilizers and protective components.

Figure 57: Grapeson a stone, Blizanci (source: promotional material)

When planting vineyards the indigenous varieties should be used as they are, with many years of cultivation, and are best adapted to the climatic conditions of the area. When planting new varieties we should observe results of its introduction, with special reference to its resistance to lack of moisture.

Figure58: Indigenous varieties -Zilavka (Source: Lasic, V.)

Also, when planting,care should be taken on the choice of substrates that are more resistant to drought. For Herzegovina,climatic conditions recommend a substrate of medium drought tolerance. Moderately resistant to drought are rootstocks of the group crosses berlandieri x rupestris and rootstock berlandieri x rupestris Ruggeri 140 and rootstock berlandieri x rupestris Richter 110. These rootstocks are prevalent in planting vineyards in the last 20 years of experience and are very good. Resistance to drought of rootstock is unexplored and should be used in selecting a good foundation of experience from existing vineyards.

During the formation of tree forms the shading of the soil should be taken into account, planting shape should allow good shading the soil, and thus significantly reduce water loss from the soil. The best growing method of shading the soil is free ray cultivation, but the worst for the work of other agricultural machines.This growing method can be used in smaller areas which are processed manually or with small machines (tiller).

Fertilization of a vineyard through agro-technical measures with which the negative effects of drought can significantly enhance or significantly diminish. Fertilization of vineyards should primarily be done in optimal quantities and should use mature organic fertilizer to lessen the effect of drought. Fertilizing with green manure will increase the negative effects of drought. Over-fertilizing of vineyards (especially nitrogenous fertilizer N) leads to increased vigor and with increasing vigor decreases resistance to drought.

With timely destruction of weeds,number of competitors for water in the vineyard reduces. It is the best to destroy weeds pre-emergence or shortly after germination, before it's developed and uses significant amounts of water from the soil.

A very effective measure to reduce damage from drought is shallow tillage which simultaneously destroys weeds and creates a loose layer of earth, preventing the loss of water from the deeper soil layers. With this measure water is held in the deeper zones of the soil for longer, where the majority of the root system of the vine is located.

Pruning vines into green reduces the amount of green mass and burden born on the vine, and thus the need for each vine for water. Pruning in the green should be carried out promptly, before the onset of drought in order to have positive effect. Untimely and excessive pruning in green can boost the negative effects of drought.

Treatment of grapevine with foliar fertilizers and preservatives based on copper may give positive results in reducing the damage caused by drought, but at the same time it can create expenses using foliar fertilizers on vineyard when it is not need or protection when there are no conditions for the development of fungal diseases. These two measures can be tentatively recommended only if the assumed damage from drought is greater than the assumed cost of implementing these measures.

5.4. Review of existing measures to combat drought in agriculture

When the situation in regards to measures to combat drought in agriculture in Bosnia and Herzegovina as a whole is observed, particularly in the region of Herzegovina, one can point out several limitations that now exist objectively in the agricultural sector.

Firstly there is almost no organized and appropriatelypaid human as well as material capacity which would create a wider, on a scientific basis, based vulnerability assessment of sectors of fruit, vegetables and wine on the adverse impact of climate change. Only after one such assessment it would be possible to engage other community resources in order to reduce the negative impact or somewhat alleviated them.

Furthermore, and also particularly important,there exists very poor existing input data which are required for making such analysis. This includes the lack of organized social exchange of relevant information that already exists but do not find their way to the end user - independent researchers, research institutions, educational institutions, etc. The reason for this is poor social organizations in this sector.In addition to the low level of awareness of the actors involved, as well as the population,there is a very great need forthe customization of everything related to agriculture to the current climate.

Lastly, we should mention that the very small and sporadic approved funds are invested with the aim of making scientific and technical studies which should be targeted as guidelines in order to adapt to the consequences of climate change.

As quick and effective measures to combat the drought,a few well tested necessary steps should be taken into account that would in any case be taken to alleviate the current restrictions listed and really improved the condition of agriculture.

The first measure would be to increase the number of physical meteorological stations in order to receive better input data for the prediction and analysis. This data would improve the system of weather forecastingand early warnings for drought.

Further measures would run, conditionally speaking, in two directions: one direction, which would be supported in agronomy as a science, and the second one would be based on the foundation of construction activity.

Of course this separation is done only tentatively and the final result in the form of an effective long-term fight against drought would be possible only by employing social direction, but it is also necessary to emphasize the differences in approaches.

Parts related to the agronomy,in short, would be based on the selection of varieties and drought resistant crops, good soil preparation (quality landscaping terraces on slopes, shallow tillage equipment for vineyards, and retrieve humus in the soil with organic fertilizer), education of farmers about drought and climate change.

The task of engineers would be to make the plan of irrigation at all levels of governance in Bosnia and Herzegovina: state, entity, cantonal and municipal, with a quality and practical water management, thus enabling high-quality battle against drought.

6. RECOMMENDATIONS

Agricultural production must be adapted to the characteristics of the climate of area-zoning. The regions of the arid and humid climates have different requirements for physiological functions of plants which depend not only on being widespread, but also on the productivity of plants. In addition to climatic differences, differences in soil characteristics and relief conditions, factors that determine the specific regionalization of agricultural crops are important. Some areas are different in the way of exploitation of the soil and the structure of sowing areas. By choosing suitable species and varieties along with other customized agro-technical measures it can help to prevent or mitigate damage from weather extremes and to achieve high yields and quality.

In order to mitigate the negative effects of drought on agricultural production it is necessary to implement appropriate preventive and direct measures at the farm level as well as at the state level.

6.1. The recommendation for the introduction of measures to mitigate drought on farm level

6.1.1. The choice of seeding and planting material

Modern agricultural production is based on the continuing need for high-quality seed and planting material. Seed and planting material is essential whennewly planting orchards and vineyards, as well as in the vegetable and crop production, and when designing urban settlements and development of spatial area in which a person lives and works. Plant material has a long-term impact on the development of crop production, as well as at the success of production of certain crops.

After the post-war reconstruction of crop production in Herzegovina, a great need for seedlings of annual and perennial plants has been imposed. The current situation in the Bosnia and Herzegovina plant nurseries still do not meet its own needs. Because the quantities of produced seedlings are insufficient, the rest are imported from other countries, often by cultivars which do not respond to our climate. Lack of planting material at the level of Bosnia and Herzegovina, the Federation of Bosnia and Herzegovina and Herzegovina spurred the formation of a large number of small nurseries - private producers on family farms. At the beginning production was organized without the necessary infrastructure and without quality stem plantations for the production of quality planting material, and without the introduction of modern cultivars. Over time, production has increased and conditions of production have been improved, but there was no planning for planting material (certain fruit species, cultivars structure, appropriate rootstocks and certain quality seedlings).

The existing environmental condition (climate, soil, geographic location and human resources) providesopportunity for intensive nursery production in Herzegovina. Transplanting is a very sensitive production, which has remarkable economic and strategic importance, because the production and introduction of new varieties are preconditions for increasing crop production and mass plant production. Particular attention should be paid to the origin and varietal purity of planting material, as well as the health of the existing assortment. The modern nursery production imposes a number of complex problems, whose successful resolution can make a successful nursery production. Prerequisites for good production are: organizationof nurseries, raising the base of good quality and healthy and thereby constantly tested mother plants, selection of the most appropriate initial planting material,the use of the most appropriate production techniques, constant control of genetic safety and health conditions (absence of virus) of seedlings, providing the best personnel in the organization of production, application of scientific and technical achievements in equipment and production technology, with the productivity, in order to offer not only quality and sanitary flawless but also relatively inexpensive seedlings. Significant achievements in all of the above are essential for the good development of the entire plant production on the basis of modern science and technology.

High quality and healthy planting material are preconditions for successful crop production.It is necessary to use the experience of developed European countries and gradually introduce them to our area. In developed countries ofthe EU,nurseries are significantly subsidized and base plantations are under the supervision of state research institutions. The products are mostly certified virus-free planting material for intensive production. Scientific institutions work on selections of indigenous varieties and the creation of new ones, and find methods of fast, high-quality and low-cost multiplication of planting material.

In accordance with the legislation in the area of Herzegovina, institutions authorized to perform professional inspection and supervision of the production of planting material is the Federal Agro Mediterranean Institute and the Federal Institute for Agriculture Sarajevo. All produced fruit seedlings and vine grafts in the 2010 fall into the category: **standard planting material** and aresold in the markwith declaration of yellow color and letters S-A.

Production of planting material is regulated by the "Law on Seeds and planting material of agricultural plants" and "Law on Recognition and Protection of agricultural and forest plants."

Recommendations for the selection of seedlings in Herzegovina

Modern nursery production imposes the need for planning annual and perennial plantations, which is reflected in the production of planting materials matched with expert opinions. One of the first steps is to organize and connect farmers and nurserymen as well as scientific and professional institutions. Joint planning of nursery production several seasons in advance with respect to the choice of species, cultivars, selection of rootstockis to ensure nurserymen the ability to produce a significantly greater quantity and quality of planting material. In particular, attention should be paid to the production and selection of indigenous planting materials that are adapted to existing conditions, especially drought as a limiting factor in the production in Herzegovina region.

Stability and development of a nursery and its competitiveness in the market depends on: the external quality planting materials (vegetative, generative and health appearance of seedlings), internal quality planting material (varietal purity, varietal identity, state of health - viruses, diseases and pests), competitive pricing and securing the necessary amount of planting material.

Development guidelines:

- determine the long-term needs of seedlings in Herzegovina;
- support cooperative relationships between nurseryman;

• establish a database of nurseries in Herzegovina with surfaces, volumes, assortment of produced seedlings;
• reduce the importation of seeds, working on organizing of domestic production;
• raise base planting material in environmentally appropriate areas, with a choice of varieties;
• in addition to base plantations, it would be necessary to establish introductioncentre, which would aim at introducing and testing new varieties and making recommendations for the cultivation of certain varieties in our climatic conditions;
• to organize the selection of indigenous and domesticated varieties resistant to drought;
• it is necessary to produce seedlings for integrated and organic production of plants, which must take place under special rules and supervision;
• harmonize legislation with EU regulations;
• support scientific research institutions for monitoring and enforcement measures in nursery production.

Each fruit species has a larger or smaller number of varieties, which differ in a number of properties: maturation time, pomological properties of fruits, fruit quality, vigor, resistance or susceptibility to various pathogens, tolerance to soil pH, tolerance to high or low temperatures according to the requirements of the sum of inactive temperature, tolerance to lack or excess of water, etc. The properties of these varieties are primarily determined by its hereditary basis, but also by the properties of the rootstock on which the variety is grafted, physio-chemical properties of soil and climatic characteristics of the living space. Therefore, when choosing a particular assortment of fruit species, all these factors should be taken into account, whereby one should not forget the demands of the market. Based on bio-ecological potential of Herzegovina it can be concluded that in the southern parts,varieties of early and late maturation can be grown (e.g. summer and winter varieties of apples, pears), as well as varieties of stone fruit (apricots, sweet cherries, cherry / Maraska variety Cherry /, Japanese- Chinese plum cultivar), almond, olive, pomegranate, fig,and peaches whose sum inactive temperature should not exceed 800-900 hours, and early varieties of strawberries. In the highlands, northern areas of Herzegovina plums, apples, pears (varieties that do not require a large number of days from pollination to fruit ripening), sweet cherry, cherry, walnut, raspberry, blackberry, strawberry can be successfully grown.

Table 25 displays a list of varietiesof certain types of fruit in Herzegovina for commercial production. It is important to emphasize that the high yields and quality can be achieved only by applying the abovepreventive and agricultural practices with an emphasis on the importance of the primary factors - application of irrigation. So, without irrigation it is not possible to talk about intensive cultivation of fruits.

Table 25: Assortment offruitfor commercialfruit productionin Herzegovina

Fruit type	Variety	Some characteristics of the fruit variety
Apple	Close	Summer variety, (matures in II half of June), sensitive tolate springfrosts. Pollinators: Stark Earliest,James Grieve, Idared, Golden Delicious
	Stark Earliest	Summer variety, (maturesbetween 1. and 15. July). Pollinators: Jonathan, J.Grieve, Golden Delicious, Idared.
	Vista Bella	Summer variety, (maturesfrom 10to 15 July). Pollinators: Stark Earliest, J.Grieve, Golden Delicious, Idared.
	Gala	Fall variety (maturesfrom the mid ofSeptember). Pollinators: Golden Delicious, Granny Smith, Jonathan, Fuji
	Elstar	Fall variety (maturesfrom the mid to end of September). Pollinators: Jonathan, Gloster, Idared, Braeburn, Gala, Golden Delicious.
	Jonagold	Fall variety (maturesfrom the mid to end of September). Pollinators: Granny Smith, Idared, Gloster, J.Grieve, Braeburn.
	Jonathan	Wintervariety (maturesfrom the mid to end of September). Pollinators: Granny Smith, Golden Delicious
	Golden Delicious	Winter variety (maturesat the end of September). Pollinators: Gloster, Idared, Jonathan, James Grieve.
	Idared	Wintervariety(maturesbeginnigOctober) Pollinators: Golden Delicious, Spartan, J.Grieve, McIntosh.
	Braeburn	Wintervariety(maturessecond half of October) Pollinators: Fuji, Gala, G.Delicious, Granny Smith.
	Pink Lady	Wintervariety (matures beginnig of November) Pollinators: Fuji, Granny Smith, Gala, Jonathan, Idared, J.Grieve.
	Granny Smith	Wintervariety(maturesin second half of October). Pollinators: Golden Delicious, Red Delicious, Gloster.
Pear	Lipanjska ljepotica	Summer variety, (maturesat the end of October). Pollinators: Rana Morettinijeva, Srpanjska sarena, Trevuska.
	Srpanjska sarena	Summer variety, (maturesat mid of July). Pollinators: Lipanjsko zlato, Lipanjska ljepotica, Rana Morettinijeva.
	Carmen (Karmen)	Summer variety, (maturesat the endof July). Pollinators: Conference, Norma, Tosca, Viljamovka.
	Etrusca (Etruska)	Summer variety,(maturesin the mid ofJuly). Pollinators: Abee Fetel.
	Viljamovka	Summer variety,(maturesin the third decade of August). Pollinators: Gellertova, Abbe Fetel, Conferance, Boskova tikvica.
	Hardenponova zimska	Wintervariety(matures in October). Pollinators:Gellertova, Viljamovka, Trevuska, Boskova tikvica, Klapov ljubimac)
	Pastorcica (Kaludjerka)	Wintervariety(matures at the beginning of October).Pollinators: Klapov ljubimac, Trevuska, Krasanka, Gelertova.
	Paskrasan (Krasanka)	Wintervariety(maturesin first half of October).Pollinators: Fetelova, Viljamovka, Boskova, Konferans, Klerzo.
Plum	Ruth Gerstetter*	European variety (maturesbeginning of July) Table variety. Pollinators: Stanley, Bistrica. Tolerant onplum pox virus.
	California blue (Kalifornijska plava)*	Table variety (maturesat the mid of July). Self-pollinating variety.
	Red beaut*	Japanese – Chinese variety (maturesat the mid of June). Table variety. Pollinators: Santa Rosa, Redhart
	Redheart*	Japanese – Chinese variety (maturesat the mid of July). Table variety. Pollinators: Santa Rosa, Burbank, Elephant heart.
	Santa Rosa*	Japanese – Chinese variety (maturesat the end of June beginning of July). Table variety. Pollinators: Redheart, Frontier, Red beaut, dzanarika.
	Bistrica (Pozegaca) ×	European variety (maturesat the end of August or beginning of September). Table variety and variety for processing.Self-pollinating variety. Sensitive onplum pox virus.

Table 25: continued

Fruit type	Variety	Some characteristics of the fruit variety
Plum	Stanley ×	Table varietyvariety for processing (matures in the second half of August). Self-pollinating variety.
	President ×	European variety (matures at the beginning of September). Table varietyand variety for processing. Pollinators: Bistrica, Stanley, Azenka, Ruth Gerstetter.
Peach andnectarine	Springtime	KM variety (matures around 33 days before variety Redhaven). Self-pollinating variety peach white meat.
	Springcrest	KM variety (matures 24 days before Redhaven). Self-pollinating variety peach, yellow meat.
	Redhaven	KM (maturesin third decade of July). Self-pollinating variety peach, yellow meat.
	Regina	M variety (matures 4 daysafter variety Redhaven). Self-pollinating varietypeach, yellow meat.
	Fayette	KM variety (matures 31 daysafter variety Redhaven). Self-pollinatingvarietypeach, yellow meat.
	Armking	M variety (matures 18 to 20 daysbeforevariety Redhaven). Self-pollinatingvarietyof nectarine, yellow-orange meat.
	Indipendence	KM variety (maturesat the same time as variety Redhaven). Self-pollinatingvariety nectarine, yellow-orange meat.
	Nectared 4	KM variety (matures 10 to 12 days after variety Redhaven). Self-pollinatingvarietyof nectarine, yellow-orange meat.
	Vivian	Industrial variety of peach (maturesat the end of July and beginning of August). Self-pollinatingvariety, yellow-orange meat.
	Fortuna	M varietyandindustrial varietyof peach (matures 5to 6 daysbeforevariety Vivian). Self-pollinating, yellow-orange meat.
Apricot	Velika rana (Grosse Fruhe)	Earlyvariety (maturesfrom the mid to the end of June). Self-pollinating variety. Table variety and variety for processing.
	Madjarska najbolja	Mid earlyvariety (matures 10 to 15 days after Velike rane). Self-pollinating. Table variety and variety for processing.
	Cacansko zlato	Mid earlyvariety (maturesat the same time as Madjarska najbolja). Self-pollinatingvariety. Table variety and variety for processing.
	Keckemetska ruza	Latevariety (maturesat the end of July beginnig of the August). Table variety and variety for processing.
Sweet cherry	Stella	Mid latevariety (maturesin fourth week, matures 21 days after variety Burlat). Self-pollinating variety.
	Lapinis	Mid late variety (matures 24 daysaftervariety Burlat). Self-pollinating variety.
	Burlat	Earlyvariety (maturesin second week, in mid of May). External pollination variety. Pollinators:Van, Sue, Lapinis, Stella, Adriana.
	Rita	Earlyvariety (matures 7 daysbefore the variety Burlat). External pollination variety.Pollinators: Burlat, Katalin.
	Gomilicka rana	Earlyvariety (matures 5 daysbefore variety Burlat). External pollination variety. Pollinators: Starking Hardy Giant, Garnet.
	Lionska rana	Earlyvariety (matures 5 daysaftervariety Burlat). External pollination variety. Pollinators: Hedelfinska, Kasinova rana, Schrecken bigarreau).
	Big Lory	Mid latevariety (matures 14 days after variety Burlat). External pollination variety.Pollinators: Burlat, Hedelfinger, Van, Lory Bloom.
Cherry	Maraska*	Maturesfrom mid-June to early July.There areself-pollinatingvarieties, partially self-pollinating andexternal pollination variety.Table variety and variety for processing.
	Rexelle	Maturesin the secondhalf of June. Self-pollinating variety. Suitablefor all formsof processing.

Table 25: continued

Fruit type	Variety	Some characteristics of the fruit variety
Cherry	Oblacinska	Maturesin lateJune.Self-pollinating variety.An excellentcultivarfor processing.
	Duga Lotova	Maturesat the beginning of July. Self-pollinating variety.Tablevariety.
Almond	Ferraduel	Maturesat the beginning of September.External pollination variety. Pollinators: Filippo Ceo, Texas, Tuono.
	Ferragnes	Matures at the beginning of September. External pollination variety. Pollinators: Ferraduel, Texas, Tuono, Filippo Ceo, Ferrastar.
	Nonpareil (Non parej)	Matures in September. External pollination variety.Pollinators: Texas, Drake.
	Troito	Matures at the end of August.Self-pollinating variety.Recommended pollinators:Ferraduel, Ferragnes, Genco.
Walnut	Franquette (Franket)	Recommendedfor cultivation incontinentalandMediterranean area.
	Mayette (Majet)	Recommendedfor cultivation incontinentalandMediterranean area.
	Sejnovo	Recommendedfor cultivation incontinental area.
	Jupiter	Recommendedfor cultivation incontinentalandMediterranean area.
	Sampion	Recommendedfor cultivation incontinentalandMediterranean area.
Fig	Petrovaca bijela	Double harvest variety (first harvestin June, second harvest in August). Table variety
	Termenjaca	Double harvest variety (first harvest in June, second harvest in August).Table variety
	Petrovaca crna	Double harvest variety (first harvest in June, second harvest in August).Table variety
	Tjenica (Zamorcica)	Single harvestwhite (matures in first decade of August).Table variety and variety for drying.
	Saraguja	Single harvestblack (matures in the mid-August). Table variety and variety for drying.
	Zelenka	Single harvestwhite(matures at the beginning of September). Table variety.
Pomegranate	Glavas	Matures at the end September and first half of October.
	Konjski zub	Matures in September.
	Slatki barski	Matures at the end of August, beginning of September.
	Sladun	Matures at the end of August, beginning of September.
Olive	Oblica	Table variety, but has high level of randman oil. External pollination variety. Pollinators: Picholine, Ascolana Tenera, Pendolino, Levantinka, Leccino.
	Levantinka	Oilvariety. Self-pollinating variety.
	Istarska bjelica	Oilvariety. External pollination variety. Pollinators: Leccino, Frantoio.
	Drobnica	Oilvariety. Self-pollinating variety.
	Pendolino	Oil variety. Self-pollinating variety.Pollinators: Leccino, Maurino and Rosciola
	Ascolana Tenera	Table variety. Self-pollinating variety. Recommendedpollinators: Picholine, Oblica, Pendolino.
Raspberry	Willamete	Single harvest variety.
	Meeker	Single harvestvariety.
	Tulameen	Single harvestvariety.
	Autumn bliss	Double harvestvariety.
	Polana	Double harvestvariety.
	Polka	Double harvestvariety.

Table 25: continued

Fruit type	Variety	Some characteristics of the fruit variety
Strawberry	Miss	Very earlyvariety (matures if first decade of May). Single harvest variety.
	Senga Precosa	Earlyvariety (matures in mid-May). Single harvest variety.
	Pocahontas	Mid earlyvariety (matures at the end of May). Single harvest variety.
	Tethis*	Mid latevariety(matures at the end of May). Single harvest variety.
	Marmolada	Latevariety (matures at the beginning ofJune). Single harvest variety.
	Raurica (Civka)	Late variety (matures inJune). Single harvest variety.
	Irvine	Multi-harvest variety.
	Seascape	Multi-harvest variety.
	Revada	Multi-harvest variety.
Blackberry	Black Satin	Matures at the end ofJulyto the first ten days ofSeptember.
	Loch Ness	Matures inJuly.
	Thornfree	Matures at the end of July to the mid-September.

**Indicatesthattherecommendedvarietiesshould be cultivated insouthernand warmerregions*
× Indicatesthattherecommendedvarietiesshould be cultivated in northernandcolder areas
KM-varietiesthat can be growninthe continentalandMediterraneanareas
M-varieties that can be grownin the Mediterranean area

Figure 59: Seedlingsof fruit trees

Selection of high quality and healthy seeds and planting material is a prerequisite for successful **vegetable** production. Production of vegetablesfrom seedlings involvesthe better utilization of seed which is especially important in expensive hybrid seed varieties. Production of seedlings is carried out under strictly controlled conditions. By using special sterilized substrate, healthy seedlings without fungal, bacterial and viral diseases are produced. Growing vegetables from seedlings earlier production in the open can be achieved, as well as the culture rotation in the production area. After transplanting, the plants continue to grow stress-free and smooth due to technological maturity, resulting in high yields. Intensive production of some types of vegetables is based on the use of grafted seedlings which have more advantages compared to conventionally produced seedlings. Grafted seedlings have exuberant growth of above-ground parts and more developed root and plants adopt better water and nutrients, are better able to withstand stress conditions such as drought, salinity of the soil, growing in monoculture and achieve greater, especially early yield.

6.1.2. Raising of anti-hail nets

The main function of anti-hail nets is to mechanically protect orchards from the hail. However, these covers greatly affect the energy and water balance of plant assembly above which are set because they represent a barrier to radiation, but also partly for evaporation and moisture preservation. Hail nets are now made of plastic material and graphite placed, usually in orchards, for the protection from the hail. The structure is composed of pillars, each bound by the system of ropes, anchors, clips and pretensioners that are covered with nets. Nets are made of materials produced on the basis of polyethylene. Nets are mostly black, but can be and gray and white nets. They are, except in color, different in chemical composition and durability. When selecting a net, the dimensions of the holes should be 4 x 8 mm.

In addition to measurements of meteorological parameters (duration and intensity of solar radiation, precipitation, wetting the leaves, soil humidity, air temperature), it is necessary to monitor the impact of the nets on quantitative and qualitative characteristics of fruits in various stages of development. Of course, semi-protected space beneath the assembly plant is significantly less illuminated than the one that is not covered.

Hail nets can cause:

• reduction of the intensity and duration of photosynthetically active radiation (FAZ) for 12-17%, and in extreme cases up to 25% (depending on the type, size and color of net)
• an increase in relative humidity 10-15%,
• reduction of wind speed up to 50%
• reduction of the variation of soil moisture,
• reduction of the air temperature during the day (1-3 ° C during the warm and hot days),
• impact on air temperature during the night and with no apparent protection from frost,
• reduction ofburn and birds damage that will further improve the quality of bark and color of the fruit.

The vitality of a tree is a feature that largely determines how the fruit will respondto the nets, while the size of the fruit with vibrant tree underneath netswill be reduced in the event of improper pruning which stimulates intense growth of shoots. Orchards protected by nets must rapidly achieve and maintain high yield and product quality in order to refund for the cost of nets and its installation.

Firuge60 (a,b, c): Modern orchards with the anti-hail nets

6.1.3. Size of plantation

Lot size is very important. Future organization of work and the ability to apply modern pomotechnics in the orchard depends on it. Plot size often varies due to terrain. It is recommended that the size of the plot, which can be mechanically process, is not greater than 6-10 ha. Plots should be oriented towards the most frequent wind. In the case that the land subject has too strong of winds or a field with a greater inclination, it is necessary that the plot is smaller in size, from 5 to 6 ha. In the case of several plots, it is recommended that all are equal in size.

Figure61(a, b):Draftand layout ofplots

6.1.4. The choice of location for crops cultivation

When raising orchards certain conditions such as climate, soil, water, exposure of field, and phytosanitary must be fulfilled. The best results are obtained when plants are provide optimal growing conditions, which are influenced by climatic conditions; therefore the seedlings of those plants that naturally grow in an area where there is an orchardshould be used.Problems with climate and land can be overcome with production in controlled (closed) areas and the use of specific substrates for plant species whose production in such a way are economically justified.

In determining the location and position of the orchard, attention should be paid to the macro-and micro-climatic conditions that are a prerequisite for successful production.

Climate

In each agricultural production, the climate is one of the basic prerequisites for successful production.Climate characteristics are determined by macro-location in which it is possible to organize the production of certain plant species. The most favourable areas for production are those which have moderate to mild winter without temperature fluctuations, as well as moderately warm summers without extremely high temperatures. Also, for the micro-location and aerated open positions, it is important to avoid the valley in which in the spring cold and moist air piles up.

Soil

Soil in orchards is an important factor in successful production, while it is important that the soil has excellent structure, fertilility and moisture, because only then the necessary optimum development is secured primarily in the root system (which should be fibrous) and whole seedlings.

Suitable land for orchards are sandy-loam soils, brown forest soil, alluvium, chernosem and other light and medium-heavy soil, permeable, with deep and fertile profile. The depth of the soil should not be less than 70 cm, provided that the active layer is fertile, moderately moist and without pedological impermeable layer. The active layer in the nursery should have good physical, chemical and biological properties, to be establishedby agro-chemical and soil analyses. If physical characteristics do not match (depth and structure of profile), such sites should be avoided because repairing the physical properties of the soil are difficult and usually economically unjustified and sites with mild, filtered and well compacted soil should be chosen. It is especially important to pay attention to the chemical composition of humus, macro and micro elements in the soil, and if there are some disadvantages, they can be repaired with fertilization before raising plantations.

Exposure of the field

Exposure of terrain, slope and elevation are important factors that affect the choice of a convenient location for orchards. In continental areas of Herzegovina the southern, south-western and southeastern exposure are used, because the fruit in such positions have enough light and heat. In sub-Mediterranean areas of Herzegovina northern exposure can be used, if all other conditions of production are fulfilled.

Flat terrain should be given priority in choosing a site because they are suitable for the use of machinery and the implementation of other agricultural measures. Also, fields with a small slope (5%) can be successfully used for fruit production.

Valleys which keep cold air,have bad ventilation and frequent temperature inversions because of fog, and usually without enough light should be avoided.

Phytosanitary factors

Contaminated areas with quarantine pests and diseases cannot be used for fruit production. The land must not contain pathogens that cause roots cancer and rot and pests such as nematode, root eaters, chafer larvae, etc. Also, the weeds can be carriers of some diseases and pests, so the land must be cleaned of weeds.

6.1.5. Weed control

The use of herbicides in the space between the rows has a downward trend towards complete abandonment. It should be noted that the use of herbicides, especially in young plantations can cause damage, slow growth, and often dry part or all of theplantation because of improper application. Total and selective herbicides can be equally harmful (Andelic 1978, Jankovic, 1989). There are many examples of raspberry damage due to improper application of herbicides based on dihlorbenila napropamide mainly due to delayed, excessive or improper application in the (mostly sandy) soils after which there is no shoots in the coming year (Misic and Nikolic, 2003). Also, inadequate application of herbicides based on glyphosate often leads to damage to the part of fruit trees, especially on the lower floors, because of the application of tiny, almost invisible particles on the leaves of fruit trees.

In older orchards during full harvestone must be careful regarding the choice of herbicides for certain species, cultivar, soil type, method of application, allowable dose and time of application. All this should be aligned with the environmental requirements of reduced pollution of land and water, and if possible to fit into the modern concept of integrated fruit production (IPV). For these reasons priority is given to the mechanical processing using mulch material to enrich the soil in the root system zone and make soil looser while maintaining soil microfauna.

Figure 62(a,b) Weed controlinorchard

6.1.6. Crop rotation

Crop rotation is a system of crop production on arable land which is the most practiced,it is a proper rotation of crops, spatial (spatial rotation) and time (crops rotation), in the production areas.

Systematic and successive rotation of cultures at the same surface has three main tasks, namely:

a) economic-technical-organizational
b) economic
c) biological

Cultivating crops in the rotation, we achieve the highest rationality and optimal biological, organizational and spatial impacts on soil and plant. Proper crop rotation archives, with corresponding production technology better compensation for the biological balance of spontaneous phytocoenoses. Crop rotation is not a "recipe", but represents,in the given situation, the best compromise solution. Any changes in crop rotation must be documented and crop rotation re-established with respect to the required rules.

Crop rotation is an important agro-technical measure in the cultivation of vegetables. The structure of crop rotation is determined by the biological properties of cultured species and has its own peculiarities in the cultivation outdoors as well as indoors. Adherence to proper crop rotation can avoid many problems in the cultivation such as deterioration of soil structure, soil fatigue, accumulation of pests and pathogens and toxins increase. In the warmer area, crop rotation with use of irrigation can intensify the cultivation of three vegetable crops in the same area during the year. The structure of crop rotation can be mixed in such a way that the main crops are profitable vegetables, while other are forage crops and leguminous species that have beneficial effects on soil structure.

6.1.7. Soil tillage

Soil tillage is applied to regulate moisture, weed control and improve the structure of the field’s layers, and plowing of fertilizers. In intensive plantations of fruit trees, autumn-winter plowing or spring is applied, according to the state of the land. Soil tillage can be performed manually or mechanically. With mechanized processing such as machines, there is minimal damage the root system. Depth of surface treatment must be adjusted so that the root system is not damaged.

In any case, often plowing or, best of all, milling is very important and useful in orchards, not only for the purpose of direct regulation of humidity, but in order to combat multiple damaging weed flora, which competes with fruit trees in terms of moisture and mineral nutrients. This allows, among other things, that the land can receive and hold more water from precipitation. Therefore, the processing of tillage in most orchards is done every 3 or 4 weeks. In order to smooth the application of appropriate mechanization spacing between rows should be 2.5 -3.5 m Space in rows is processed manually or with mechanization or weeds are suppress with herbicides, but with the necessary caution in their use.

Figure 63: tillage between rows inorchard

Tillage in drought conditions

This year, in terms of climate,will be rememberedas extremely dry. Agriculture is an economic activity on which climate (bad) conditions have a major impact,and that's why we call it "a factory under the open sky." If we cannot affect the schedule, the type and amount of precipitation, we can with certain agro-technical measures preserve the moisture that is already in the ground.

Deep plowing (winter furrow) is a basic measure of tillage in crop cultivation, which certainly should be done as soon as weather conditions allow for it, at the latest during the end of November. Plowing will improve soil structure, has favourable influence on the water-air regime in the soil, suppresses weeds and pests, plows in crop residue, and introduces manure into depth of most of the mass of roots (basic fertilization). Plowing has a beneficial effect on the microorganisms in the soil which break down plowed harvest residues and ultimately leads to the formation of humus. With timely and well-executed plowing the soil becomes loose, because it increases ventilation volume and can accumulate a greater amount of water.

The depth of primary tillage needs to be changed;plowing should not be at the same depth every year. This avoids the creation of a plow sole or compacted soil layer that prevents water intake and hence nutrients from deeper soil layers.

It is also essential to plow at the right time, when the soil is not too dry, nor too moist. In this way, we will comply with one of the requirements of cross compliance, and good agricultural practices –with the appropriate use of equipment, a favourable soil structure will be maintained, as well as agricultural mechanization.

After plowing,early in spring (beginning of March),the winter furrow should be close in order to preserve soil water collected in the autumn - winter period. In dry years this agro-technical measure is gaining more importance. If the soil is left in the winter furrow in spring until the seeding deadlines, during the rise in temperature of the soil and the air the surface layer will lose significant amounts of stored water. In dry periods agro-technical measures should be adjusted to the new conditions in order to preserve as much ground water, evenly distributed in all layers of the soil, because that is only way we can provide the proper growth and development of plants.

Tillage improves the thermal regime and water/air regime of the soil, also with tillage climate can be corrected, primarily with accumulations, conservation and drainage measures. Tillage allows root penetration into the deeper layers of the soil, so the plants better tolerate drought. The treated soil retains more water than in untreated and thus create moisture supply for periods of drought.

Tillage system must be adapted to the characteristics of the soil, the requirements of cultured species, but also climate change. For spring sowing of vegetable crops recommendation is to conduct a deep autumn plowing before the expected rainy maximum to accumulatemore winter moisture in the soil. In our dry conditions, it is necessary to plane or harrow soil early in the spring to close the winter furrow and thus prevent the loss of harvested winter moisture. Pre-sowing soil preparation should be done immediately before sowing as it would otherwise have lost a lot of moisture through the evaporation. However, because of reduced accumulation of water in dry years it is recommended to apply a system of reduced tillage. Reduced tillage increases soil water conservation. After sowing in warm, dry springs it is necessary to roll soil to establish capillary rise and to bring water to the seeds. The problem is the formation of crust and rolling shall not be the last measure of tillage, but performs combined with harrowing. Cultivating the soil destroys the crusts and reduces capillary rise and water loss through evaporation, which contributes to better moisture preservation. Although earthling of crops is referred toas measure of tending broad row crops, is not recommended to earth crops in dry conditions, it increases the surface area of the soil, and thus the loss of water by evaporation. In extreme drought conditions in order to prevent evaporation of water from the deeper soil layers it is best to avoid milling or any similar processing of soil.

It is important to choose the proper direction of processing on slopes because such land is subject to the water erosion. On slopes soil must be processed horizontally to reduce surface runoff and improve water absorption into the soil.

6.1.8. Fertilization and nutrition

Soil suitability for cultivation of fruit trees are of particular significance given that perennial fruit crops remain for many years on the same grounds. The number of features and characteristics of the soil, which is necessary to consider when planning the use of land for fruit is very large and depends on the particular type of fruit. Generally, the most important properties of the soil, which must be analysed, include the basic substrate, organic depth, particle size distribution, texture, water-air relations, compaction, the presence of groundwater, soil reaction, humus content, lime content and nutrient content. When assessing the suitability of the land mentioned, soil properties are analysedand features of the land, in relation to the requirements of individual fruit species, are determined based on the existing restrictions for its intensive cultivation.

Table 26:Dominantrestrictions and measuresfor soil improvement

		Possibleagro andhidroreclamationproceduresfor the removal ofrestrictions
Physical	•unfavorablesoil structureandstructuralinstability of theaggregate •soil compaction • poor water/air relationships •stagnation ofrain water • shallowenvironmentaldepth •occurrenceof groundwater •stoniness •rockiness	•organicfertilizationandliming •tillage, verticaldeeploosening, undermining •improvement ofsoil structure, tillage, verticaldeeploosening, undermining •basic and detaileddrainage •in the karststoneremoval, scarifying • deepprocessing •removalof rocksincaseofrockiness •organicfertilization •reclamationmineralfertilization •calcification •selection of appropriatesurface •salt rinsing
Chemical	•lowhumus content • lack ofnutrients •soil acidity • content ofcarbonateand lime •soilsalinity	

On the basis of the limitations, measures for improving land are recommended in the form of agro-and / or hydro-meliorative, which are designed and executed in cultivating fruit crops.

Agromeliorative measures and / or maintenance of soil fertility for fruit cultivation

The suitability of the soil for the cultivation of fruit trees has particular significance with regard to the perennial fruit crops that remain for many years on the same grounds. The number of features and characteristics of the soil, which is necessary to consider when planning the use of land for fruit, is very large and depends on the individual fruit species.

In the fruit areas, numerous restrictions are identified varying in intensity as well as a number expressed in certain types of fruit. Within the framework of intensive farming it is necessary, therefore, to plan the removal of all restrictions from the point of soil fertility conditions required for the cultivation of fruit trees and fruit development.

To remove the restrictions, following agro-meliorative works are recommended: organic fertilization; meliorative fertilization, mineral fertilization; calcification; vertical deep loosening; undermining; plowing; removal of stone and rock removal. To remove restrictions following hydromelioration procedures are recommended: basic drainage; detailed drainage and salt removal.

Fertilization of fruit trees is a very important agro-technical measure, since fruit trees spend large amounts of nutrients for their growth and development. There are many factors that determine the amount and type of fertilizer to be applied. Some of them are: the condition of the soil in the orchard, and the prevalence of specific nutrients in the soil, the amount of soil organic matter, soil pH reaction, soil structure, plant density in orchards, the exuberance of varieties, age of fruit trees, i.e., whether the trees are young or tree have entered into cropping, in which stage of growth and development of the fruit trees are in the moment of fertilization, the requirements of individual fruit species to fertilizers, climatic conditions.

The proper selection of types of fertilizers, application method for fertilization, and time (moment) of application of fertilization can reduce the negative impact of the drought. Mineral fertilizers may be applied over the surface or through the irrigation system (fertigation). It is also important that when applying fertilizer on the surface, ground with fertilizers has to be plowed and then the fertilized area must be soaked. When applying fertilizers, we must observe in which stage of development certain types of fruit are, which will certainly affect the selection of types of fertilizers, and if it comes to mineral fertilizers that will affect the selection of the formulation of that fertilizer (ratio of nitrogen: phosphorus: potassium).

During the period of drought smaller amounts of nitrogen fertilizer should be introduced, because it encourages strong vegetative growth, which again increases the transpiration due to the large mass of vegetative organs.

Also abundantly fertilizing with certain fertilizers can affect the stronger occurrence of some diseases and pests on fruit trees. If fruit trees have received, in time, necessary quantities of phosphorus and potassium, then during the period of drought these trees will not have the problem of the lack of these elements, moreover, the tree will be even more tolerant to the impact of drought. Of course it should be pointed out that it is certainly beneficial to use organic fertilizers in orchards which enrich the soil with organic matter and a certain amount of moisture, and improve soil structure and encourage the work of microorganisms in the soil. The zone around the tree to which the fertilizer is applied is also very importantbecause the older trees have certainly more widespread root network, i.e., outside the circumference of the crown, than younger trees (which also saves fertilizer).

Fertilization must maintain the required level of nutrients in the soil and the necessary balance between individual nutrient elements.

In the production of **vegetables**, fertilization is an important agro-technical measure which provides nutrients and maintain soil fertility for the plants. Fertile soils are stable under adverse weather. In order to ensure optimal plant growth and achieve high yields and quality in vegetable growing the balance between mineral and organic fertilizers is needed. This will ensure the development of the plants in good shape, which are more resistant to adverse environmental conditions.Nitrogen, phosphorus and potassium have great significance in the metabolism of vegetable crops. Nitrogen stimulates vegetative development of the plant and it is necessary to add it moderately so the plant will be firm and resistant to external conditions. Potassium, which is usually the most consumed in fruiting, increasesthe plants'turgor and regulates the mechanism of stomata function,increasing resistance to drought. Potassium and phosphorus have a positive impact on reducing transpiration. The positive effect of phosphorus fertilizer on the plant is to stimulate the development of plant roots so it can better exploit water from deeper soil layers. Fertilizing should be planned based on the results of chemical analyses of soil and plant material.

Organic fertilizers have a positive effect on many properties of the soil, especially on soils that are poorly stocked with humus. Fertilization with organic fertilizers is a biological measure for the conservation of soil and water in order to repair and maintain soil structure.

For organic fertilizer, mature manure which is added to the basic fertilization is commonly used. Vegetable crops react differently to manuring. Onions and root species cannot tolerate direct manuring, or some kind of leafy vegetables that have shorter vegetation. On the other hand, the types of vegetables that have longer and lush vegetation of above ground mass extremely well receive manuring. The land fertilized with manure has a higher resistance to compaction.

Plowing green plants into soil (green manuring) is also a way to bring organic fertilizer to the soil. Due to weather conditions in areas with mild winters more suitable is autumn sowing of green mass. On arable land green mass is mainly sown as interpolated crops.

In periods of drought for vegetables it is best to add fertilizer through an irrigation system which is known as fertigation. Generally, the modern technology of vegetable production cannot be achieved without the use of a fertigation system. In this way, the vegetables are continuouslysupplied with water throughout the vegetative cycle and in it are melted and precisely dosed necessary plant nutrients. Irrigation method "drop by drop" is technologically the best way of distributing water and nutrients inthe fertigation system, although other methods of irrigation can also be used. Fertigation, among other things, encourages the exuberance of crops causing shading of the soil and thus it reduces the temperature in arid conditions.

In terms of soil moisture deficit, therecommendation is to apply foliar fertilization because vegetables have the ability to acquire nutrients through the leaves. The addition of liquid and water soluble leaf fertilizers withdifferent formulations achieve high yields and quality. The application of fertilizers with increased concentration of calcium prevents premature defoliation and falling of fruit, which happens in drought conditions. Foliar fertilization is justified when drought has damaged the plantation in order to stimulate the regeneration of plants with easily available macro and micro nutrients. Recommendation for foliar fertilizers is after sprinkling or other irrigation methods because it will prevent the occurrence of blight on leaves and fruits.

Lately, bio-metabolic fertilizers (biostimulators) that stimulate plants in poor conditions to exploit their biological potential are becoming more interesting. These are solutions that stimulate the metabolic activity of the plant, stimulate root development, improve the absorption of water and nutrients, dynamism metabolic processes after various stressful situations such as temperature changes, poor physical properties of the soil, regulate pH, etc.

The positive effect of the adoption and retention of water, especially in arid regions have different hydro-conditioners (hydropolymer). These are crystalline substances that have a high ability to absorb water and then cross to the gelatinous state. Water is slowly and steadily released and is available for plants without adding extra water. Application of hydro-conditioners has multiple uses including a reduction in the need for watering and reducing depreciation and stress in drought conditions. Hydro-conditioners can be applied in the production of vegetables in open and protected areas, as well as the addition of substrates and compositions for the production of seedlings.

6.1.9. Mulching or soil mulching

Mulching or spreading is the process of covering the ground in an orchard with rotting organic matter that enriches the soil with humus (decaying hay, straw, leaf litter, corn, grass, ...).

Under mulch,microorganisms and soil fauna are activated (earthworms) that use mulch for food and gradually enrich the soil with humus, improving the structure.If material rich in cellulose are used, than there is a lack of nitrogen, so it should be addedas fertilizer. Mulching is usually done in the spring after spring tillage.The layer thickness should be 10 to 15 cm, and care should be taken not to mulch 40 to 50 cm along the trunk because of the rodents.

Benefits of mulching:

• preventing excessive evaporation of moisture from the soil,
• enhanced accumulation of precipitation (less surface runoff),
• reduced erosion,
• no weeds, and no tillage,
• improves soil structure,
• improved the reception of K and P and other elements,
• improving the thermal regime of the soil and protect the roots from frost,
• less damage and contamination of fallen fruit before harvest,
• easier access to the orchard at any time (especially for protection).

Disadvantages of mulching:
• There is a risk that the mulch can burn - fire,
• under the mulch, and in it,mice can reproduce as well as other rodents that damage the root,
• the crimson pests that can survive in the spring can develop in greater numbers.

Mulching is best tolerated by pomes fruit (apples and pears), and berries (strawberry, raspberry, currant, blueberry), and the worst by peach.

Mulching of soil with inorganic substances

Typically it is used in the cultivation of strawberries or the cultivation of fruit trees in the dense set. The material for mulching is the black plastic film,or so called glass wool. Planted strawberries are increasingly cultivated on films with two rows and shoulders. The concept of growing strawberries in pure land without foil and mulching is almost abandoned.

Irrigation is imperative here, without which high yields cannot be possible. Significant contribution to it is cheaper plastic sheeting and irrigation systems so that nowadays we have strawberriesyields over 20:25 t / ha. Also, greenhouse production of strawberries (and sometimes raspberries) is a reality in the race for higher yields and better price that is achieved with earlier ripening fruit (Misic and Nikolic, 2003).

Figure64 (a,b): Mulch in the strawberry plantation

Figure65: Experiment with different mulch materials

Figure 66: Machine for distribution of mulch materials

In intensive **vegetable** production, soil covering is the regular procedure. On the covered ground there is reduction in direct action of solar radiation and reduction in evaporation, meaning unproductive evaporation of water from the soil surface. Thus water and soil thermal regime is improved. In such conditions, the work of soil microorganisms is stimulated, and increased production of carbon dioxide occurs, which is in this way more accessible to plants. Mulching disables weed development, and excludes the use of herbicides. The ground can be covered with a variety of organic and polymeric materials. In the production of vegetables, soil is covered with black opaque, translucent and white polyethylene film. The greatest application has black polyethylene film which increases the temperature of the soil which is important in winter and early spring production.

White, silver or black-and-white films that reflect most of the solar radiation have the opposite affect, resulting in lower soil temperatures. These films are used in the warmer period in late spring and summer production of vegetables.

6.1.10. Production in greenhouses

Growing vegetables in protected areas can be viewed as one of the means of production technology adaptation to climate change.Unlike outdoorproduction, in protected areas (greenhouses, tunnels) with usage of modern technological processes,vegetation factors can be modified and adapted (water, heat, light, air, nutrients) to the needs of the plants. This reduces the negative impact of the external environmentalfactors on the growth and development of cultivated varieties of vegetables. The protected area can be very intensively used throughout the year with proper change of cultures, ensuring high yield and efficiency.

The choice of location for this kind of production depends on many factors. It should be emphasized that the availability of sufficient quantities of good quality water for irrigation is important because in protected areas waterfor plants is provided only artificially. In protected areas, in relation to the cultivation outdoors, water consumption is higher, primarily because ofhigher temperatures due to the "greenhouse effect." Plants grown in protected areas have less developed roots, lush aboveground mass and achieve higher yields per plant and per unit of area. Accordingly, it is necessary to ensure optimal quantity of water and nutrients for plant'sneeds. For most types of vegetables, the most suitable system of irrigation is “drop by prop”, which is stocked with a fertirigation dispenser for water soluble fertilizers.For uniformly wetting theextensive application, there are automated sprinkling systems that are mounted on the pipes under the roof structure.

To regulate the microclimate conditions in order to protect the plants from the occurrence of heat stress, various cooling systems depending on the type of protected area are used. Most often the air temperature is lowered by ventilation of the space. In terms of increasingly frequent climate change accompanied by extreme temperatures, preference should be given to protected areas with modern equipment, installed to regulate the microclimate. Larger facilities are equipped with automatically regulated side and roof ventilation. Also, the air temperature can be lowered with clouding, micro sprinklers system, "The Fog", watering the roofs, fans through the "Fan-Jet" and adiabatic cooling, which is the most efficient and most modern way of cooling space in the summer.

To reduce the heat inside the protected area during the warmer days,different ways of shading are applied, from the simplest, such as painting the roof and the side surface with white paint and placing different networks and thermal curtain in modern facilities. Material for blinds can be of different colors, density of weaving and intensity so the solar radiation can be reduced in different percentages. It is important that in shaded areas there is still enough light for normal development of the process of photosynthesis.

As well as outdoors, in protected areas the soil is mulched with different materials depending on the terms of production.During summer cultivation it is the best to cover soil in white or black and white films in which the white side is up. This reduces the heat within the protected area and reducesthe loss of water by evaporation.

Figure67: Accumulation of water for protected areas
(Source: Sefo, E.)

The latest technology in the production of vegetables in greenhouses is the hydroponic farming system-cultivation without soil. In this way it is possible to organize the production of vegetables at sites with low quality of soil or without soil. Hydroponic production method allows complete control of the amount of water in the production system.

Water consumption is lower -up to 70-90% compared to other conventional methods of production - and it is possible to organize production in areas where water supplies are limited. There are several techniques of hydroponic production with substrates (organic, inorganic, and synthetic) and without substrates (hydroponics, aeroponik). As a medium for rooting commercially, the most used are blocks of stone wool. With a fully automated system, plants are regularly supplied with water and nutrients that are readily available, which leads to higher yields in comparison to other ways of growing vegetables.

Figure68: Growingcucumbersonan inertsubstrate (Source: Sefo, E.)

6.1.11. Raising the modern system of farming "at the hand’s reach"

The system of cultivation of fruit trees implies a harmonious relationship between planting density and represented growing shape, or an interactive relationship between planting density, growing shape and selected combinations of variety/rootstock (Micic and Djuric, 1994). In order to efficiently perform necessary, agro technical and management measures in orchards, the trend is to form lowercultivation form with the maximum number of trees per unit area, for optimal production and usage of (living) space. It is of particular importance to define specific management measures for certain systems of cultivation, especially for the formation and proper replacement of a fruiting tree.

In a series of management measures, pruning undoubtedly is one of the most important. This measure directly affects the growth and productivity of fruit trees, or establishes and permanently maintains a balance between vegetative and generative potential.

Bearing in mind the experience and present trends in countries with high intensity fruitproduction, orientation should mainly be on the cultivations of high density planting, habitus of low vigor (fruits“at the hand’s reach") and a shorter period of exploitation (Gvozdenovic, 1996; Mantinger, 1993). In such continuous highly intensive technology in orchards,pruning of low intensity is recommended as well as the application of other management measures on fruit trees: bending branches, swaddling, shortening, scoring the trunk, etc. to achieve early entry into fruiting period, which establishes and maintains a balance between growths and yielding (Velickovic, 2002).

Of particular importance is the proper and timely execution of green pruning (single or double), as well as thinning of fruits which presence in the crown of the fruit tree must be proportional in relation with the number of normally developed and undamaged leaves.

Any deviation from the above management measures leads fruit production to an extensive level of low profitable production, which is unacceptable, in the smaller, and the major production areas.

In the world, and partly in our country, the dominant place belongs to cultivation forms (Slender spindle) and modifications thereof (especially apple, pear and peach). Existing forms of slender spindles and attempts to find new, more productive for certain types of fruit trees, directly depend on the character formation and fouling native tree (Christoph Innerhofer, 1974; Fidelghelli and Et Rigo, 1995).

In the intensive and high intensity plantations, certain advantages are exhibited by forms of modified spindle shape to the shapes of the formation: superspindle, Hai-Tek and bent spindle, then the modification of spindle shape according to the number and position of the central rail: V-Guttingen, Mikado and Drilling systems and Verona spindle, Verona vase and Pal-spindle, as well as less common newer forms Tatura Trelis, Solen, Solakse, Tesa, etc. (Lespinasse, 1987, Van der Ende, 1984).

Based on past experience we can say that the greatest productivity per unit of area is achieved with the cultivation form superspindel, then "V" planting, and then the smallest: the palmette. However, superspindle is economically justified only in terms of higher prices and extra first-class, while the "V" planting, four-axis systems and bent spindle are far more profitable (Micic et al., 1998).

Starting from the different production conditions and variety characteristics,it can be concluded that the high productivity per unit area requiresraising plantations (with appropriate varieties) in a dense planting of 2500-5000 plants per hectare at the recommended intervals of planting 3.5 to 4 x 0, 5 - 1 m

6.1.12. Recommendations for introduction of the network for irrigation

Agriculture in Herzegovina is a very important part of the economy because it provides food for a significant population in rural and in urban areas. A significant part of the workforce in rural areas is linked to agriculture and as such plays a very important role in the lives of people in those areas.Compared with other sectors, agriculture is very slowly recovering after the completion of the war. Generally speaking, agriculture throughout Bosnia and Herzegovina, including Herzegovina,which is unfortunately no exception, is characterized by small and fragmented holdings. Poor technical equipment and old pre-war technology is mainly used on these lands.

In the past 120 years, i.e. since the 1894, when on the territory of B&Hwas the first irrigation system, until today, there was no systematic and organized financing and construction of the irrigation of agricultural land. Activities to build irrigation systems have always been driven by the level of government in periods when it suited the interests of the ruling structures. The period from 1949 to 1962 is characteristic, when in the area Herzegovina irrigation systems in spaces of 8,550 hectares were built and the period from 1972 till 1991, when the Sava River basin approximately had 11,600 hectares of agricultural surface covered with irrigation systems.

Irrigation is the artificial bringing of water to farmland in order to meet the needs of plants for water, i.e., in order to ensure constant high yields of agricultural crops. Lack or shortage of water causes drought effects and reduces or completely destroys the crop yields. The world pays great importance to irrigation (265 million hectares, 18% of the total arable land), and in B&H tradition exists only in part of Herzegovina (Gatacko field, Ljubusko-Vitinsko field).

Agricultural activity requires large amounts of water. In developed countries, the irrigated land is increasing but unfortunately in the rest of the world practices of sustainable irrigation are rare. In the world, almost half of the water produced in the irrigation system is lost due to damaged pipes and inefficient irrigation systems(Organization for Economic Cooperation and Development, 2001).

Lack of water during the vegetative season is a key factor that limits the development of agriculture, especially in Herzegovina. If we take into account the climate change, this area could suffer the greatest damage during dry periods, and it is necessary to begin the reconstruction of irrigation systems and water reservoirs. Only 4,360 acres in this area are irrigated and the potential area that could be irrigated stretches over 74,000 hectares (Regional Environmental Center, 2000). In 1990, Bosnia and Herzegovina had 11,660 irrigated hectares.

Currently there is a present phenomenon of water use for agriculture without any quality control and quantity of water. It is necessary to establish a good legal system to ensure the implementation of control mechanisms and field inspections.

Irrigation as amelioration measure aims to compensate for the lack of water that occurs in the growing of agricultural crops, or correction of natural water regimes artificially adding water at a suitable moment for the proper development of the plant to raise the threshold achieved in the production of agricultural crops in the years that are dry - that is all frequent occurrence in the past 20 years. Also, irrigation allows better utilization of land by introducing a second harvest. Irrigation can, to some extent, compensate for the negative effects of reducing supplemental chemical agents and enables the production of "health food".

The downward trend in annual rainfall, especially during the growing season has led to increased interest in irrigation in Herzegovina.

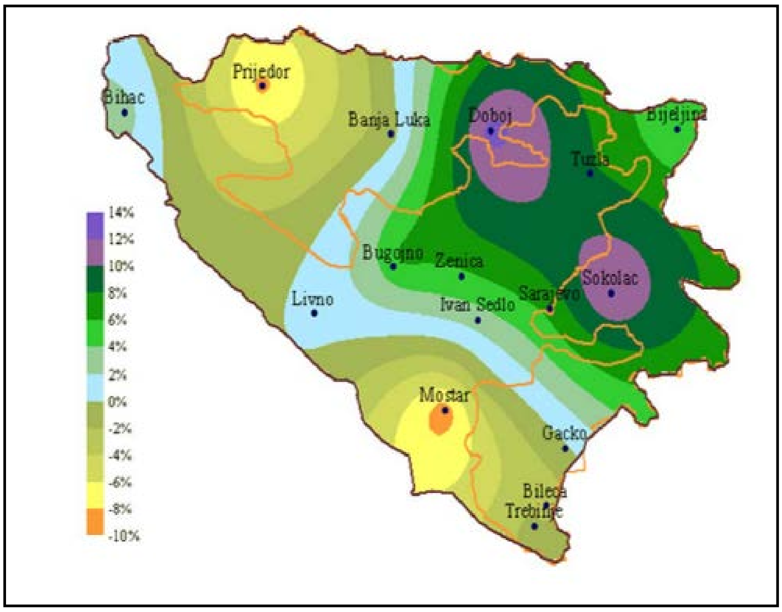


Figure 69: Spatial distributionof annualincrease/decreasethe volume ofrainfallfor theperiod1999 to2008thcomparedto the reference periodbetweenin 1961-1990.
(Source: First National Communication ofBosnia and Herzegovinainaccordance with theUN Framework Conventionon Climate Change2009.)

*Initial National Communication of Bosnia and Herzegovina in accordance with the UN Framework Convention on Climate Change from 2009*gives a dramatic picture of the reduction of the volume of rainfall for the measurement period of 1999 to 2008 compared to the reference period 1961-1990, particularly in the area of Herzegovina in Mostar area. In the immediate area of Mostar the reduction amounts to over 10%, while for the whole Herzegovina decrease may be noticedfrom 2-8%! This data shows how important it is to create a sustainable irrigation system in the near future.

The lack of irrigation is one of the major limitations of agricultural development in connection with the production and the other branches that depend on it. This has significance for overall stability, especially on food sectors of the economy. In addition to preventing drought and natural disasters in agriculture, irrigation generally increases yields, increases the degree of land use and opens up the possibility of other sowing, with a significant increase in the quality of the fruit.

In some areas in Herzegovina there are examples of technologically advanced and cost-effective agricultural production. Usually, those are small individual producers or producer groups in limited space. Their further progress, and the progress of potential new producers should be encouraged by successful examples, but it is limited due to the lack of production infrastructure, where to ensure the water is one of the fundamental links.

Systems of water gates and distribution of water for irrigation are extremely expensive and their economic efficiency is generally based on economies of scale. Small farmers do not have any knowledge nor the means to build such systems, and support from the state or local government is uncommon in developed countries. Efficient irrigation systems provide cost-effective water and the technology of agricultural production with irrigation provides farming of attractive and profitable agricultural crops.

Agricultural producers, who apply modern technology and produce a generous income culture, have introduced irrigation to their land. Unfortunately, there are a very small number of such producers.Due to lack of irrigation infrastructure,even this small number of producers are copping to secure water for irrigation in a variety of ways. In such a situation it is not surprising that the water used for irrigation is taken from household water supply systems.

Quality solutions for irrigation infrastructure will enable the rational management of water resources, which has a positive effect on the proper utilization of drinking water and reducing the price of water for irrigation, and the cost of agricultural production.

To ensure a satisfactory income from a small area, it is necessary to produce labour and capital intensive crops, which generally require irrigation. Therefore, the preparation of project documentation **(Plans for irrigation)** on improving irrigation is major contribution which government structures at all levels of government can provide with the aim of creating a modern and competitive agriculture in the existing natural and social circumstances.

Applicable irrigation systems

Since irrigation is as old as human civilization, and to date four methods have been used, there exists many ways and many irrigation systems.

The first method was the **<u>surface irrigation</u>**. The fundamental feature of surface irrigation is tha, a thin layer of water covers the soil or flows on the surface. Then it is absorbed into the rhizosphere zone and is used for plant growth and development.Methods and diversified surface irrigation systems are still used in a lot of areas in the world, especially irrigation furrows, but in our conditions theyare no longer used, so there is no need to process and recommend surface irrigation in this study.

Method of underground irrigation leads water though the open channels or underground pipes to the production plot. From the canal or underground pipes, due to capillary forces, water infiltrates horizontally and vertically to the rhizosphere zone where plants use it. Having in mind that underground irrigation has many drawbacks in practical application, very little is used in agricultural production, which is why we think that it is not promising, nor effective enough for use in Herzegovina.

Sprinkler irrigation methods have been introduced at the beginning of the last century with the development of technology and more efficient machines. Advanced technical equipment has enabled bringing water under pressure to the production areas and spraying the whole area, providing the soil or plants with water.In the last century, with the sprinkling method, several methods and systems of irrigation have been developed. It began with diversified systems of classical raining, then diversified systems of self-propelled devices, as well as multiple systems that perform hydromatic form of spraying and dispensing water as needed to soil, crops and the objectives to be achieved in production.

The method of localized irrigation is the latest method, which was applied starting from the middle of the last century. Today there are severaldripping irrigation systems and irrigation systems of various mini sprinklers. With dripping irrigation, water is supplied at a low pressureto the production area, in which only part of surface area that is in the vicinity of the cultivated plant is wetted. Irrigation with mini sprinklers’ water is also rationally spent, and localized irrigation is particularly important for areas that have limited amounts of water. Drippingsystems and mini-sprinklersystems are made of plastic material. They can be applied to all soils, all topographic conditions and for all crops under field conditions and protected areas (plastic and glass green-houses).

In addition, these systems are requiringlow levels of driving energy, they save water and perform precise dosing of water. It is significant that localized irrigation systems are functional, reliable, and have the possibility of electronic control of the entire system and automatic control of its individual parts. With these systems, optimum moisture in the soil can be maintained, the required level of nutrients for plants grown and favourable microclimate conditions throughout the growing season crops can be kept. Based on the above facts it is recommended that for the growing of annual and perennial variety of crops, modern irrigation systems be applied.

Modern systems are the newest method of sprinkling systems and dripping systems and mini-sprinklers or systems of localized irrigation.

However, the choice of irrigation systems for specific agricultural production will depend on several factors:

1. cultivated culture,
2. size and shape of the production areas,
3. configuration of terrain,
4. type and location of water sources and
5. available quantity and quality of water.

Moreover, when choosing the irrigation system, care should be taken on:

1. first characteristics of the ground,
2. road and canal network,
3. supply cost,
4. maintenance costs of the irrigation system.

Since the choice of the system in practice is most affected by the size of plot and type of crops, *Table 27* shows the elements that assist in the selection of the irrigation system in practice.

Table27:Choice of method, type and system of irrigation depending on the culture

Plot size (ha)	**Cultivated culture**	**Irrigation method**	**Type of irrigation**	**Irrigation system**
up to 0,3	fruit, vegetable, wine grapes,nursery, field cropsandfodder crops that are plantedin rows,	localized	dripping	different types ofdrippers
	culturesof high density planting	localized	minisprinklers	different types ofnozzles
0,3-5	fruit, wine grapes, nursery cultures	localized	dripping	different types ofdrippers
			minisprinklers	different types ofnozzles
0,3-5	Vegetable, crop and forage crops that are planted in rows and culture of high density planting	localized	minisprinklers	different types ofnozzles
		conventionalsprinkler	conventionalsprinkler	Portable andsemi-
5-30	Fruit, grapes, nursery culture and vegetable farming and foraging cultures in rows	localized	dripping and minisprinklers	different types ofdrippers and minisprinklers
		sprinkler	automotive	Typhon
	Vegetable, crop and fodder crops of high density planting	sprinkler	conventionalsprinkler	Portable andsemi-
			automotivede	Typhon
				Siderainywing
more than 30	Fruit, grape vine, vegetable, crop and forage culture in rows	localized	drippingminisprinklers	different types ofminisprinklers
		sprinkler	automotivede	Typhon
	Vegetable, crop and fodder crops of high density planting	sprinkler		Siderainywing
			Hydromatic	Line
				Pivot

Figure 70: Linear machine for irrigation length of 760 meters fed from an open channel (Source: materials of company Valmont, Lipovac)

Although the lack of water can be somewhat compensated with agro-technical measures, irrigation usesdirect measures to combat drought and certainly the priority measures for sustainable vegetable production.

Irrigation can best influence the microclimate of the production area. In the irrigated plantation of vegetables the utilization of the natural fertility of the soil, applied fertilizers, protective equipment, etc. are improved. With the aim to rationally consume water in the process of agricultural production, new irrigation systems have been created. In vegetable production the most rational system of irrigation has been dripping, especially in combination with the application of polyethylene mulch films.

Recommendations for development ofirrigation network (for fruit)

In regards to the fruit production in Herzegovina, given the cultivation in very different climates, natural precipitation is not sufficient to meet the needs for water, which primarily refers to the arid and semi-arid areas in the presence of high temperature, but also in areas which includes the semi-humid but with inadequate distribution of precipitation. In such conditions, irrigation is required to be measuresd and implemented in accordance with the pedoclimatic conditions of the site, in order to meet the needs of fruit trees for water in order to achieve high yields of adequate quality.

Irrigation of fruit trees is carried out in several ways, and it is essential to provide sufficient quantities for plants readily available water in the zone of active root system. The best moment for the beginning of irrigation is to be determinedby the water content in the soil, especially if they are reliable measuring devices.

Technical minimum of soil water content is at lento capillary humidity at 60-65% PVK, on the medium-light to medium-heavy soils, or about 70% of PVK on lighter soils. The value of technical minimum actually depends on the water and physical properties of each type of soil, and represents the moment when water passes from easily moving the harder movable.

For the fruit production, water is essential in order to increase fruit and achieve higher yields, but it is no less important for the growth of the tree.

In practice, the most commonly used mode of irrigation is to the critical periods in relation to the water. Most fruit trees consume water from the end of flowering until the end of an increase in fruit size. Critical stages of development in relation to water are blossoming, growth of leaves and shoots, the formation of embryos and increase the fruits size.

The first irrigation should be done ten days after flowering, if the spring was dry and winter was poor with rain. The second irrigation is done at the beginning of the seventh month, in the period of greatest increase in vegetative organs, when flower buds for the next year are formed and fruits grow. That is when there are the largest evapotranspiration requirements of external environment, and most fruit trees consume water, and the period is relatively lacking in rainfall.

The third irrigation is done at the beginning of the eighth month, during the increase of fruits size, which isnearing harvesting at the end of the eighth month and during the ninth month. The fourth irrigation is applied only in varieties of apples and pears for winter consumption, but is done 25-30 days before harvest.

The most common methods of irrigation in orchards are irrigation: "drop by drop", mini sprinkler irrigation and sprinkler irrigation.

Figure71: mini sprinkler irrigation

Figure72: Irrigation “drop by drop”

Figure73: sprinkler irrigation

Irrigation of individual fruit species

Apple irrigation

In the apple orchard drip irrigation is recommended because it gets water to the plant continuously and achieves major water savings. Short distances between the portions of water are recommended, with limited quantity portions of water is to ensure that the plant easier adopts the water. Lack of water through the critical stages of development can result in a decline in fruit, reduced yield and faster completion of the season of growth and maturation.

The average annual irrigation amounts to 2500-3500 m3/ha. It is recommended to use the irrigation system, "drop by drop" and irrigation with the optimal amount of water, because it would allow use of the water and its retention in the soil as well as fulfilment of PVK. Time of irrigation is in critical phenological phases: the maximal growth, change of color and fruit ripening, after harvest, July-August (when the flower buds are differentiating).

Pear irrigation

Pear trees are quite tolerant to drought; however, significantly better results are achieved in plantations which are optimally supplied with water. Tolerance of trees to the lack of water depends on the selection of the rootstock. It comes from the different penetration and distribution of root system on surface and in depth. Water requirements are determined by the time of ripening of pears.

In most of our regions in which it pear is grown, rainfall is from 500 to 600 mm per year, so the irrigation is necessary. Pear tree seedlings are especially vulnerable to high level of underground water. However, a moderate level of underground water works very positively to its development. In addition to soil moisture, relative air humidity is significant for growing pears. It is especially important at the time of fertilization, development and growth of the fetus and in the days with extremely high temperatures. In stunted combination of pear on quince transpiration can often be greater than the suction power of roots so leaves are suffering, it cantake away water for summer-growth, and cambium activity decreases and then increases. The most favourable relative humidity is of 60 to 70% during the summer months, while lower than 30% in combination with other unfavourable factors lead to physiological disorders in plants. To prevent transpiration,work in the world is done on antiperspirants and spraying the leaves with water in the critical days.

Irrigation of peaches and nectarines

Peach is irrigated in the dry regions where the sum of rainfall during the year is under 600 mm/cm2. Water quantity for irrigation depends on the soil hydrothermal coefficient of the region, the yield level and age of peach orchard. They are in the range of 350-500 m3 per hectare or 500-1000 l per tree.

The peach orchard is irrigated before blossoming, after thinning of fruit, during the filling of fruit (20-30 days before ripening), and in very dry regions irrigation is done over the winter or late autumn for reserve, after falling of leaves. Some recommend one watering before the start of forming floral origins (late July or early August) when watering will extend ripe of the fruit in early varieties of medium and medium-late ripening. Watering at the end of the growing season can extended increase of shoots, which are entering green into winter dormancy and it can freeze in winter and even during weakest frosts. Watering just before the beginning of fruit ripening of peaches, often delays ripening or causing mass cracking of fruits, which are large and beautifully colored but unusable as table fruit. This can cause severe losses in the production of peaches, so this irrigation is more harmful than those peaches that were left without it.The fruits after such irrigation are weaker and poorer in color and in dry substances, reducing the quality of fruits and reducing theability to transport and storefruits in a warehouse.

The peach orchard is irrigatated though the canals, pools (where 6-8 trees are surround with the small soil walls), by dish and rain. Nozzles should throw away the rain just below the crown;not wet the fruit and leaves. Irrigation water for a peach orchard has to be without the presence of harmful bacteria, toxic substances, and with a low content of lime.

Before irrigation of the peach orchard on heavier soil, monitoring of forecast of meteorological services for the respective region should be done. If such a peach orchardis watered with plenty of water today, and the next day heavy rain falls, in this case the land is saturated to the PVK, the root of the peach begins to suffocate without oxygen. Afterwards strong blightappears on the crown of peaches and growth of the fruits and shoots almost stops. In order to prevent such consequences on heavier soil, peach orchard is watered more frequently and with smaller amounts of water. After watering,shallow plowing is done in the peach orchard.

Plum Irrigation

In addition to light and heat, water belongs to the group of the basic factors for a successful growth, development and the fruiting of plum. Quince, apple and plum make up the group which need more water than other deciduous fruit trees. Plums cannot live without water. The required amounts of water are providedby precipitation and irrigation.

Homemade plum thrives best in regions with the annual sum of precipitation of 700-1100 mm, vegetation sum of rainfall 350-600 mm and relative air humidity of 75-85%. For normal growth, development and fruiting of plum requires equally and necessarily sufficient wetting of soil, during the entire period from the beginning of the growing season to fruit ripening. The plum initially consumes large amounts of water. Plum is the most sensitive to drought at the time of pitted forming (about 30 days after the end of flowering). If at that time there is lack of moisture, it can create a massive falling of set fruits (size of a hazelnut), as well as abnormal development of the fruits that remain on the branch. In strong drought (high water deficit), which usually occurs during the summer months, the leaves can take water from twigs and plumfruits. In such conditions, fruits remain small, premature ripening and mass of it fall before harvest, and their quality is not satisfactory. In condition of excess moisture in the soil,plum rootschoke (asphyxia due to lack of oxygen), and the tips of branches dry.

One irrigation requires about 30 mm of water, and on the heavier soils 40 mm. Forplum watering, the recommended method is dripping irrigation because the plant continuously receives water and because of the great savings on water.Short intervals are recommended between watering in small amounts of water to ensure that the plant can easilytake water.

Surface irrigation systems are not recommended. It is necessary to conduct chemical and bacteriological analysis of water every 3 years.

Apricot irrigation

For apricot, some argue that it is resistant to drought. According to the resistance it is classified in second place, just after almonds. However, many tests of apricot resistance to drought deny these allegations. Apricot cannot be classified as the fruit trees resistant to drought, but on the contrary, among the more important continent species that are susceptible to drought (Richter, 1928-1929).

Huge rainfall during flowering and fruit ripening also unfavourably affect the success of growing apricots. At the time of flowering it affect the poor pollination and fertilization which can reduce yield, and during the ripening of the fruit,cracking of the fruit epidermis occurs, thus reducing quality, and in both cases, prolonged rainfall enable the development of fungal and other diseases that attack and damage flower, fruit, leaf and sometimes the whole tree.

Cherries irrigation

Dripping irrigation is a recommended method in watering the cherry, because it is the most rational. Irrigation is practiced in critical periods such as during fetal growth, changes in color and fruit ripening and after harvest.

Pomegranate irrigation

To accomplish abundant yield of good fruit quality it is necessary to provide an approximate amount of water as with citrus. Irrigation is required to achieve an abundant, high-quality fruit. Pomegranate can withstand long dry periods.Although the amount of fruits produced are not large in drought conditions, trees-shrubs can survive for years. After that, if properly irrigated, these trees will deliver good fruits. The trees will flourish and bear fruit during plentiful summer rains. Then the fruits will be softer and more sensitive to transport and storage. Since the period of the fruit development is usually ruled by great heat with a deficit of moisture in the soil, it is necessary to provide 2-3 abundant waterings in July and August. Ittakes about 500 m3 of water per hectare for each watering. Without regular watering, especially in dry years, plantation cultivation of pomegranate has no prospects. Throughout the growing season, it is necessary to maintain adequate soil moisture, especially before the harvest season. This procedure will reduce fruit cracking. If the year is dry, it is necessary to irrigate every four to five days throughout the growing season. Non-continuous irrigation of pomegranate causes fruit cracking, it occurs because the enormous influx of water from the roots to the grains. Prolonged drought and lack of irrigation have consequences on the annual harvest. There may be long-term negative consequences.

Walnutirrigation

For successful cultivation of walnuts the length of its vegetation is important. Specifically, in the inland area of our country, the growing season (theoretically since the beginning of April to the end of September) for a late nut (as well as other fruit trees that require long vegetation) is not long enough, so in the fall (with early autumn frosts) fruits cannot ripen, and one-year shoots cannot mature, which in sharp winter can freeze (together with fruitful buds). Each fruit, as well as walnut,is more sensitive to winter frost of buds, shoots and multi twigs and branches before it enters the deep winter sleep (late autumn), as well as when it enters deep winter sleep (so-called physiological rest) and enters into ecological (forced) rest. Through the ecological idle,walnut has passed "hibernation", often in January, increased winter temperatures slightly motives circulation of juices and then often in February very low temperatures occurs, which cause freezing. Walnuts, which have shorter vegetation (which tree mature by the end of the growing season) and those which are in good shape (which is not exhausted by droughts, plant pests, overflowing of fruit) will better endure low winter temperatures. Late spring frosts causesfreezing of expelled shoots already at 0 ° C to -1 ° C. It is estimated that for the successful cultivation of walnuts about 750 mm of annual rainfall is enough, but well distributed. For a more dry climate, such as ours, coast summer irrigation of walnuts would be required, with monthly amounts of 40-50 mm of water. For intensive plantation and cultivation of walnuts,deep and permeable soil should be chosen, the soil reaction of pH 6.5-7.5 with 2.5-3% of humus.

Strawberry irrigation

Proper watering is very important from the standpoint of maintaining a soil moisture regime, but also in terms of possible corrections of microclimate, primarily the correction of high soil temperature and low layer of the atmosphere, especially in night hours during the warm nights and during fruiting and harvesting.In the open field when establishing plantations at high summer temperatures, it is desirable to initially use the system for micro-spraying regardless of the use of system drop by drop, which is used for fertigation. High humidity and cooling foil and seedlings contributes to more uniform and faster growing and increasing the percentage of adaptation of frigoscions.

Although the atmospheric conditions largely are uncontrollable, in the intensive cultivation of fruit, fruit growers can significantly to reduce potential damage with timely implementation of agro and management measures, starting from designing plantation with protective netsand irrigation systems,and through the proper set of fruit load, conducting winter and summer pruning, balance fertilization and selection of the highest quality clones.

Growers who own the netshave reduced the damage from blight to an acceptable 5%. Continuous irrigation and fertigation with timely chemical fruit thinning generate the required size of the fruit and avoid the alternative fruiting.

For fruit growers who do not have nets, it will be necessary to introduce, as a defence against the sun's burns, treating the fruit with medium based on kaolin clay (Surround, CutiSan), wax based emulsion (Raynox), calcium carbonate, forming a white coating on the fruit,which reflects certain spectra of solar radiation.

Abscisic acid in experiments showed significant results in preventing damage caused by drought.

When it comes to fruit colouring,it is much harder to change the environmental conditions in terms of temperature and humidity. There is a possibility of spraying to try to reduce the high night temperatures, but this is economically not very profitable and requireshuge amounts of water. With proper management and balanced nutrition, one of the promising solutions to achieve better colouringis to place reflective foil on the ground between the rows, which reflect sunlight to the tree crown. A lot can be achieved by selecting clones with intense colour. If we talk about chemical ways to improve colouring, then with more or less success use of preparations based on thiocyanate, daminozide, paclobutrazol and ethephon has been recorded.

Fruit species' needs for water depend on several factors: fruit species and varieties (during maturation), the substrate on which fruit species are grafted (varieties), plant density in orchards, direction of rows in the orchard, the development of trees and age of trees, the amount of nature (starting yield, full productivity), soil type and physical and chemical properties of soil, slope and exposure, meteorological factors (temperature, precipitation, wind). The above text has explained ways of irrigation, as well as the amount of water needed for each type of fruit.

Table 28 shows the total annual rainfall and the rainfall during the growing season required for certain types of fruit.

Table28:Total annual amount of the rainfall and the amount of rainfall needed during vegetation

Type of fruit	apple	pear	plum	peach	apricot	sweet cherry	cherry	almond
total annual rainfall needs (mm)	600-1060	600-1000	600-1000	500-700	500-700	800-1100	650	500
rainfall needed during vegetation (mm)	600	600	350-600	300-400	300-400	500	500	n/d

Table28: continued

Type of fruit	walnut	fig	pomegranate	olive	blackberry	raspberry	strawberry
total annual rainfall needs (mm)	750	300-800	300-800	300-500	>800	>800	>800
rainfall needed during vegetation (mm)	n.d.	n.d.	n.d.	n.d.	>400	>400	>400

**n.d. no data in available literature*

Irrigation of vegetable species

To determine the start of irrigation it is necessary to determine the water content in the soil. For this purpose, various precision measuring devices are used, which greatly simplifies the intervention of irrigation regardless of the changing climatic conditions. Irrigation should not be delayed, as thisis often what happens when watering is determined based on the condition ofcrops.

Figure74: Moisture meter *Figure75: Measuring soil moisture in plantation of cabbage*
(Source: Sefo, E.)

It is believed that the soil for growing vegetables in a zone of active rhizosphere must be supplied with water within the limits of 70-90% PVK of the soil for water. Lowering the soil moisture to 60% of field water capacity of soil growth of many vegetable crops is significantly slowed, while at lower water content development gradually stops.

Adoption of water in the soil depends on the environmental conditions, plant type and root development.Although some types of vegetables (watermelon, cantaloupe, carrots, potatoes) can draw moisture reserves from deeper soil layers, however in drought conditions, fruits and tubers are smaller, and roots in carrots is shorter and often irregular in shape. The quantity and availability of water depends on the texture and content of organic matter in the soil. The lack of easily accessible water is particularly pronounced on lighter soils, so the minimum technical lento capillary moisture is attained earlier.

The literature identifies various data on necessary amounts of water for irrigation of vegetables. According to Matotan (2004) these amounts are ranging from 2000 to 4000 m3/ha. Standards for irrigation and number of irrigation should be adjusted to the needs of species for water and production conditions (*Table 29*). In doing so, the amount of water that is added with irrigation (irrigation cycle) is the difference between the PVK and the current state of moisture in the soil.Withspecies which are reproduced by seedlings (cabbage, lettuce, tomatoes, peppers) usually the first irrigation is done in smaller cycles during transplanting to encourage better receiving and achieve optimal assembly. Second, irrigation is usually done after three to five days when the empty spaces are filled. After planting of transplants,irrigation is not done forthe next ten to fifteen days to encourage better rooting. The growing season is typically irrigated by shifts which length depends on the species, variety, growth stage of development, soil and climatic conditions in particular year.

Irrigation of vegetables in our production area is carried out in different ways, which depends primarily on the requirements of plant species, type of production and the degree of sophistication of the technological process and the availability of appropriate techniques.

Although there are numerous ways of irrigation, modern technological processes of vegetable irrigation are usually carried by sprinkling methods and localized methods of irrigation - dripping (drop by drop) and mini sprinklers which water distributors are usually made of plastic material or aluminium alloy of different profiles, with drip nozzles or droppers with various design.

Table 29: Approximate number of irrigation and water demand

Type of vegetable	Number of irrigation	Needed amounts of water for 1 ha in m^3	
		for one irrigation	total
Tomato	6-8	400	2.400-3.200
Paprika	10-12	400	4.000-4.800
Early cabbage	5-7	300	1.500-2.100
Late cabbage	6-8	300	1.800-2.400
Salad	3-4	250	70-1.000
Carrot	5-6	300	1.500-1.800
Green beans	4-5	300	1.200-1.500
Cucumber	7-8	300	2.100-2.400
Watermelon	1-2	400	400-800
Melon	1-2	400	400-800
Potato	2-3	30	600-800

(Source: Popovic, 1984)

Sprinkling irrigation of vegetables is very popular because water is distributed over the surface in a way that simulates the natural rain. The most effective way of sprinkler irrigation is achieved by using self-propelled devices of different technical performance.

Sprinkling irrigation is applied in protected areas. Depending on the requirements of vegetables that are grown, nozzles are adjusted so that irrigation could be completed through mist or larger water droplets. Sprinkling irrigation system increases the humidity, which favours leafy vegetables-lettuce, Swiss chard, spinach, brassicas, as well as root vegetables. Sprinkling irrigation system favoursfruiting vegetables like peppers and cucumbers. If irrigated by sunny weather, the passage of air through the water droplets can lead to the appearance of sun burns on healthy leaves.

Irrigation system drop by drop has been increasingly used in the production of vegetables in open areas and in enclosed spacesdue to a number of positive characteristics. Water is accurately led into the root zone of plants in a small, but sufficient amount. By reducing losses due to runoff or evaporation of the surface,saving of water is achieved, which is especially important in dry regions. It is typically used in the cultivation of vegetables which,because of contracting diseases of overhead parts, does not suit sprinkling watering system - for example, tomatoes, watermelons and melons. The pipe system of irrigation drop by drop is placed on pre-prepared flower beds for planting vegetable plants. Prepared billets and placed drip tubes areusually coveredwith a plastic film, and then the planting of seedlings into the holes in the foil is performed. The role of the foil which coversthe irrigation area is manifold, and in this case to prevent excessive water loss through evaporation and unwanted infestation of the soil. This method of irrigation is not suitable for the types of vegetables that are grown in dense sets (carrots) because of greater production costs.

Simultaneously with irrigation,water soluble fertilizers (fertigation) in optimal quantities are added to plants, which increase safety and productivity. The hydroponic method of fertigation supplies plant with nutrient solution.

With mini sprinklers irrigation, water falls to the ground in the form of a mist or a small stream.Irrigation of crops and soil increases water loss through evaporation especially in dry and windy areas. In comparison to dripping irrigation, water is distributed evenly in the root zone, which is important in the production of root vegetables. Mini sprinklers have extensive application in the production of vegetable transplants as well as to regulate the microclimate in protected areas.

6.1.13. Raising windbreaks

Windbreaks are important for the protection of soil and plants from wind gusts and maintenance of favourable microclimate for plant growth. Windbreaks are formed by planting several parallel rows of trees perpendicular to the direction of the most frequent winds. More severe winds create mechanical damage to plants and facilities for growing crops (protected areas). Harmful effects of wind are manifested by a sudden change in temperature, reduced concentration of carbon dioxide, increased loss of water by evaporation and transpiration, which reflects negatively on the intensity of photosynthesis of cultivated plants. In protected areas it creates an unfavourable microclimate for growing crops due to lower temperature and relative humidity. To conserve energy for heating the protected area, with a selection of suitable sites for construction, the recommendation is to raise the mechanical or biological shelters around the protected area.

6.2. Recommendations for the introduction of measures to mitigate drought at the national level

Based on data and studies on climate change and its impact on the area of Herzegovina it is clear that this area increasingly encounters drought as a natural phenomenon. It has a very negative economic impact on the production of fruits, vegetables and viticulture.

In order to begin work on the systematic elimination of the consequences of drought occurrence it will be required to include the competent authorities and institutions as well as scientific and technical institutions in the process of mitigation the effects of drought.

The task of scientific, educational and professional institutions would be to develop and implement training programs on climate change on agriculture in the wider social structure in particular those related to agriculture.

From the relevant ministries (state, entity, cantonal) it is expected to introduce appropriate measures of incentives and subsidies for owners of farms affected by drought.

In dry periods there is an increase in the risk of fire and reduction in the possibilities of effective eradication and control of these phenomena.

Recommendations to reduce the devastating effects of drought, risk reduction and rational water management:

1. Development of irrigation plans according to which sufficient water for irrigation of arable land is ensured, and also would create the conditions for intensive agricultural production.

2. Construction of multi-purpose, small artificial reservoirs (especially in the upper, less densely populated parts of the basin), as well as the construction of water tanks in the lower parts.

3. In order to pre-reduce the risk of damage from drought and large scale damages which can endanger people and material goods, it is necessary to ensure the reduction of losses in water supply systems, reconstruction and creation of rapid flow through the system.

4. The introduction of new technologies in the production process, reducing the need for additional water while improving the quality of water used and discharged (especially in large industrial plants - which are carried out in the action through the ***Plan of development with measures and deadlines for reducing the impact on the environment***).

5. Engaging an additional amount of water from available or prepared new sources, improving the supply to the population already covered through the public water supply, and expanding them into a bigger number of areas in which there has been a reduction of inflow into the tanks.

6. Protect and develop existing sources, and find new ones, to secure additional water in the affected areas.

7. Perform acceptance and capping of high water when they occur and are available in terms of needs through the construction of artificial reservoirs which, in addition to electricity generation, create conditions for the development of tourism, provide flood protection for downstream areas, and provide water for irrigation.

8. Plan and provide transport water tanks for rehabilitation needs of the most vulnerable consumers, which requires systematically acquiring and maintaining a sufficient number of vehicles.

9. It is necessary to provide a backup of water, construction or installation of the water tank, etc.. for an effective protection against fire (particularly in the open air).

6.2. 1. Improvement of genotypes

The task of the science on heredity and breeding, among other things, is to developvarieties for growing in changing climatic conditions. One of the priority objectives of the breeding program of scientific institutions of each country certainly has to be the selection of varieties with resistance or tolerance to drought. The negative impact of drought is possible to overcome with the physiological mechanisms that increase tolerance to drought.

Most cultivated crops are sensitive to high temperatures and drought during flowering, and one of the directions of breeding procedures are to obtaincultivars with the corresponding time of flowering. The purpose of the new selection is getting these varieties to have a deeper and more developed root because it will better tolerate drought.

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