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RESEARCH ARTICLE

THE EFFECT OF ECOLOGICAL AND CONVENTIONAL CULTIVATION METHODS ON MORPHOLOGICAL ANDCHEMICALPROPERTIES OFPEPPER (CAPSICUMANNUUM)

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Abstract

Organic farmingisaproductionsystemthatmaintainsthehealthofland, ecosystems,andpeople. It relies on ecological processes, biodiversity and cycles adapted to local conditions,instead of using resources with side effects as in conventional production. Crop management inorganic agriculture differs from conventional production primarily because synthetic preparationsfor plant protection, mineral fertilizers, and seeds of genetically engineered varieties may not beusedin organic production.The research aims to compare the effect of the method of pepper grow in the open field wherecompletely natural conditions prevail, with organic and conventional methods of cultivation andtoestablish how it affectsthe quality of thefruit.For the experimental work, the culture of pepper belonging to the top of the most sought-aftervegetables in Bosnia and Herzegovina was taken. The most important conclusions made after theresearch work results are: Fruit weight and yield are proportional to the method of cultivation,meaning the variety and hybrid had the highest values in conventional cultivation, as well as fruitlength.The fruit diameter and the pericarp thickness have approximate values between the twomethods of cultivation, the amount of vitamin C in the Amanda variety in organic farming istwice less than in conventional farming, while the Dimentio hybrid has a significantly highervalue of vitamin C, especially in conventional farming, Higher values of acids are recorded intheorganiccultivationmethod.Inthetestedsamples,thetotalamountofsugar(totalinvert)is lower or approximately equal to the natural invert (reducing sugars), and a higher value ofsugarwas recorded in conventional peppercultivation.

Introduction:-

Organicpeppergrowingisincreasinglypresentinourareasbecauseconsumerswantfoodproduced without the use of pesticides and mineral fertilizers for health reasons. According todata between 2010 and 2018 (FiBL, 2018), Bosnia and Herzegovina recorded an increase inorganicproducers,sothatnumberincreasedfrom27in2010to251in2018,whichisasatisfactory figure given that organic agriculture in this country is still developing. Pepper is ahighly valued vegetable, rich in medicinal ingredients, and is therefore recommended in the diet.Itis most often usedasfresh food, as asalad, singleor with othervegetables.

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Pepper production in BiH takes place in two different climatic areas, namely in the area ofHerzegovina with a Mediterranean climate and the area of Bosnia with a temperate-continentalclimate. Two different climatic zones ensure continuous pepper production during the spring andsummerperiods. Pepperproductionareas in BiHamountto around 3,600 ha.

The main elements of organic production systems are good soil management that leads to goodfertility,maintainingahighcontentoforganicmatter,highmicrobiologicalactivity,goodsoilstructure,andapreventiverat herthanachemicalapproachtoweed, disease,andpest control[1].

Demandandconsumptionoforganicproductsandprocessedproductsaregrowingineconomicallydevelopedcountries,andprod uctionis"moving"tolessdevelopedcountriesorless developed areas of the same country [2]. Pepper in our country is grown as an annual crop.The goal of cultivation is fruits that are harvested when they reach the size, shape, and colorcharacteristicofthevariety.Harvesttimeisintechnologicalorphysiologicalmaturity,depending on the further use of the fruit. In some varieties, physiological and technologicalmaturityoverlap [3].

Well-structured and moist soils are suitable for their cultivation, while it is more sensitive duringdrought.It is desirabletosupport the growthoftherootsystembyproperfertilization [4].

The fruit is hollow, of various shapes, sizes, and colors. It consists of the pericarp, placenta, andseed.

Thepericarpconsistsoftheexocarp, mesocarp,andendocarp [3].

The success of vegetable production largely depends on the agro-ecological conditions in aparticulararea. Themostimportantagro-ecological conditions areclimateandsoil [5].

Pepper is one of the vegetable crops with the highest water requirements. In full vegetation, it isnecessary to ensure between 30 and 40 mm (l/m2), and the critical growth phase is the flowering,germination, and fruit development [6]. Due to its small root system, pepper uses water from thesurface of thesoil [7].

The plant is not able to use nutrients from the soil without a sufficient amount of water, whichcanoftenbeprovided only by irrigation [6].

Peppersareamongthecropsthathavehigh-temperaturerequirements[8].Fornormalgerminationof peppers,a temperature higher than14°Cisrequired,while theminimumgerminationtemperatureis11°C.Pepperisahighlyvaluedvegetable,richinmedicinalingredients, and therefore recommended in the diet. The best and healthiest to eat is fresh,uncookedpepper, and itsfleshy, fertilepart is considered medicinal.

Pepper is a biologically high-value vegetable that is distinguished by its extremely high contentofvitamins, alkaloids, pigments, and volatileoils that giveitaspecifictaste[9].

The richness of vitamins and other useful ingredients make the pepper especially valuable forhuman health because it improves the viscosity of blood in blood vessels and has a beneficialeffect on heart function. The highest concentration of vitamins C, A, and E are in the pericarp ofpepper[10].

The antioxidant properties of pepper provide protection against carcinogenic components anddelayaging [11, 12].

Materials And Methods:-

TheexperimentwassetupinMay2021intheruralpartoftheGračanicatowninanopenfieldat an altitude of 400 m. The "Amanda" variety and the "Dimentio" hybrid were tested in organicand conventional cultivation methods. The experiment lasted 5 months (mid-May 2021 - mid-September2021).Theplotinwhichtheprotectionwasperformedwithconventionalphytopharmaceuticals was separated from the plot with the implemented organic protection. Twoexperiments were set up with their controls, i.e., without any treatments, as indicated in Table 1.In this experiment, we tried to compare the properties of the pepper fruit concerning the methodofcultivation, protection, and fertilization.

Table1:- Interpretationoftheexperiment.

Label	Interpretation	Numberof plants
A1	PeppervarietyAmandainorganicprotection	16
D1	HybridpepperDimentioinorganicprotection	16
A2	PeppervarietyAmandainconventionalprotection	16
D2	HybridpepperDimentioinconventionalprotection	16
CA	ControlofpeppervarietyAmanda	4
CD	ControlofpepperhybridDimentio	4

Plot I was an experiment of pepper variety "Amanda" and "Dimentio" hybrid with organiccultivation. Manure and compost were used for plot fertilization. Natural preparations from plantsolutions and products of animal origin were used for plant protection, which is allowed inorganic farming. Since natural preparations do not have a curative effect, their use was appliedpreventively several times during the growing season. During the vegetation, weed protectionmeasureswere carried out by regularhoeing.

Plot II was an experiment of pepper variety "Amanda" and "Dimentio" hybrid with the use ofphytopharmaceuticalproductsforplantprotectionandmineralfertilizers,accordingtoapredeterminedplan.Water-soluble(Yaracrystals)fertilizerswereusedasmineralfertilizers.Tables2 and 3 show the experiments used in organic farming, their active substances, doses/concentrationsofapplication,thetotalnumberoftreatments,andthetimeoftreatmentapplication.

Table2:-Treatments/preparationsusedinorganicfarming,theiractivesubstances,ASconcentrations,used dosage/concentration.

Treatment/Preparation	Activesubstance(AS)	AS concentration	Dosage/concentrationapplications
Milk+baking soda	Milk+baking soda	-	10%+0,4%
Nettleleafsolution	Nettle	-	10%
Composttea	Compost	-	10%

Table 3:- Total number of treatments, treatment time, and withdrawal period of preparations used inorganicfarming.

Treatment	Totalnumber oftreatment	Treatmenttime	Withdrawalperiod
Milk+baking soda	15	Every7-10 days	None
		startingfrom June 7	
Nettleleafsolution	15	Every7-10 days	None
		startingfrom June 3	
Composttea	12	Every10 days	None
		startingfromMay22	

Sincenotreatmentusedinorganicfarminghasawithdrawalperiod,thetreatmentswererepeated every 7-10 days, depending on weather conditions. Nettle leaf solution has repellentproperties against aphids. Nettle extract cannot destroy aphids, but its odor repels them andprevents their further spread. Milk in combination with baking soda is used to prevent blight.Milk is a good wetting agent, and baking soda creates an alkaline environment that is not suitableforthedevelopment of fungi.

Table 4:- Treatments/preparations used in conventional farming, their active substances, ASconcentrations,used dosage/concentration.

Treatment/Preparation[1]	Activesubstance(AS)	ASconcentration	Dosage/concentrationapplications
Force	Tefluthrin	15 g/kg	10kg/ha
PrevicurEnergy	propamocarb	632,4g/l	2l/ha
	fosetyl	332,5g/l	
RidomilGoldMZ68WG	metalaxyl-M+	40 g/kg	2,5 kg/ha
	mancozeb	640g/kg	
Tonus	Acetamiprid	200g/kg	0,25 kg/ha

[1]Tradenamesofthephytopharmaceuticalproductsused ontheexperimentalplot

Polux	Deltamethrin	25g/l	0,2 – 0,7l/ha
Quadris	Azoxystrobin	250 g/l	0,75 l/ha
EquationPro	Famoxadone	225g/kg	0,5 kg/ha
	Cimoxanil	300g/kg	
Affirm	emamectinbenzoate	9,5g/kg	1,5 kg/ha

Table 5:- Total number of treatments, treatment time, and withdrawal period of preparations used inconventional cultivation.

Treatment/Preparation	Total number oftreatment	Treatmenttime	Withdrawalperiod
Force	1	Beforetransplanting	Depending on thevegetablevariety
PrevicurEnergy	1	Aftertransplanting	3Days
RidomilGoldMZ68WG	2	6-8leavesand	21 Day
		beginningofformation	
		offruits	
Tonus	2	6-8leavesand2weeks	14 days
		aftertransplanting	
Polux	1	Beginningofformation	7Days
		offruits	
Quadris	1	Fruit growth	3Days
EquationPro	3	Fruit harvest	7Days
Affirm	2	Fruit harvest	3Days

Results And Discussion:-

Table6:- ResultsofsoilfertilitytestingforsampleI.

Test parameter	Unit ofmeasurement	Testmethod	TestResults
pH(H2O)	-	BAS ISO10390:2009	6,64
pH(KCl)	-	BAS ISO10390:2009	5,91
Hummus	%	QMS-UP-7-27	0,9
CaCO3	%	QMS-UP-7-11	0,1
TotalN	%	BAS ENISO11261:2000	0,06
Phosphorus(P2O5)	mg/100g	QMS-UP-7-23	1,68
Potassium(K2O)	mg/100g	QMS-UP-7-23	34,1

Table7:- ResultsofsoilfertilitytestingforsampleII.

Testparameter	Unit ofmeasurement	Testmethod	TestResults
pH(H2O)	-	BAS ISO10390:2009	6,46
pH(KCl)	-	BAS ISO10390:2009	6,13
Hummus	%	QMS-UP-7-27	1,3
CaCO3	%	QMS-UP-7-11	0,22
TotalN	%	BAS ENISO11261:2000	0,04
Phosphorus(P2O5)	mg/100g	QMS-UP-7-23	8,06
Potassium(K2O)	mg/100g	QMS-UP-7-23	107

Accordingtotheresultsofphysiological/substitutionacidity(KCl),sampleIbelongstomoderately acidic soil type (pH 5.91), as well as sample II witha pH of 6.13. The optimal soilpH for growing peppers is 5.8 - 7.5 [13], therefore soil samples I and II belong to the appropriatepHrange.

The humus content in sample I is 0.9% and in sample II 1.3%, meaning that they belong to lowhumussoilsbecausethe lower limit of humus content is 2%.
The content of calcium carbonate (CaCO3) in sample I is 0.1%, meaning it is poorly carbonatedsoil, as well as sample II with 0.22%. Sample I is on the border between the very poor and poorpercentage of total nitrogen, while sample II belongs to the group of very poor supply with totalnitrogen.

The sample I belongs to the group of very low supply of phosphorus in the soil, while sample IIbelongstothegroup of lowsupply of easily accessiblephosphorussoil.

SampleIandsampleIIareclassifiedaswell-suppliedwithpotassiumsincesampleIhas34.1mgof potassium per100 g ofsoilandsampleIIhas 107 mg ofpotassium per 100g ofsoil.

Table8:- MorphometricpropertiesofpeppervarietyAmandaandDimentiohybrid.

Label of theexperiment	Fruitweight (g)	Fruitlength (cm)	Fruitdiameter (cm)	Pericarpthickness (mm)
A1	102	10,5	4,8	5,2
D1	140	13,7	7,0	6,3
A2	95	12,0	5,1	5,3
D2	152	15,3	7,2	6,5
CA	90	10,2	4,8	5,2
CD	127	13,3	6,9	6,1

Compared to similar studies, listed values of morphometric properties of pepper [9] in this studymostly correspond to the results of conventional cultivation, while the morphometric propertiesrelatedto organic farming areslightly lower.

Different irrigation intervals have a significant impact on pepper yield [14]. However, sincedifferentirrigationtreatmentsdonothaveasignificanteffectonthetotalamountoffruits,i.e., theyieldofpepperfruits,theresearchindicatesthatgrowingpepperondifferentsubstrateshasanimpact on fruit heightand fruit quality [15].

Table9:- Values ofvitaminCcontentinthetestedsamples(mg/100 g).

Sample label	I	II	III	Meanvalueofvitamincontent C(mg/100 gsample)
A1	70,24	71,58	70,84	70,88
D1	102,88	110,06	105,46	106,13
A2	141,64	141,32	142,07	141,67
D2	180,40	181,88	180,74	181,00
CA	101,40	117,14	103,32	107,28
CD	104,42	104,48	103,95	104,28

Table 9 shows that the highest mean measured value of vitamin C is in sample D2 (181.00 mg /100 g of fruit), i.e., in the pepper hybrid Dimentio at the conventional method of cultivation. Thelowest mean value of vitamin C is in sample A1 (70.88 mg / 100 g of fruit), i.e., in the peppervariety Amanda at the organic method of cultivation. A higher concentration of vitamin C can beexpected with better plant lighting and a sparse composition, which is also a recommendation foroutdoorcultivation, althoughcertaindeviationsarepossibleduetoexternal influences [9].

Table10:- pHsamplesresults.

Sample	pHvalue
A1	5,16
D1	4,87
A2	5,10
D2	5,33
CA	5,37
CD	5,38

The highest measured pH value is in the CD sample, i.e., control experiment of hybrid Dimentio,while the sample CA - control experiment of Amanda variety had an approximate value. Thelowest pH value is in the sample D1 - hybrid Dimentio in the organic method of cultivation,namely 4,87.

Recent research [16] has shown the pH of peppers ranged from 4.72 to 5.29, which are someapproximatevalues of this study.

Table11:- Test resultsofdirectlyreducingsugars(naturalinvert).

Sample label	Calculation	Naturalinvert(%)
A1	$\frac{29,5}{4\times 50,0002}\times 1$	2,36
D1	$\frac{29,2}{4\times 50,0366}\times 1$	2,33
A2	$\frac{30,6}{4\times 50,0406}\times 1$	2,44
D2	$\frac{30,3}{4\times 50,0130}\times 1$	2,42
Sample label	**Calculation**	**Naturalinvert(%)**
CA	$\frac{30,8}{4\times 50,0205}\times 1$	2,46
CD	$\frac{32,5}{4\times 50,0415}\times 1$	2,59

The CD sample has the most reducing sugars (2.59%) - control of Dimentio hybrid, and the D1sample has the least reducing sugars (2.33%) - Dimentio pepper hybrid in organic cultivation.Othersampleshadapercentageofreducingsugars between thesevalues.

Table12:- Total sugartestresults(total invert).

Sample label	Calculation	Totalinvert(%)
A1	$\frac{11,7}{10\times 50,0002}\times 1$	2,34
D1	$\frac{11,2}{10\times 50,0366}\times 1$	2,33
A2	$\frac{12,2}{10\times 50,0406}\times 1$	2,43
D2	$\frac{11,2}{10\times 50,0130}\times 1$	2,24
CA	$\frac{11,7}{10\times 50,0205}\times 1$	2,34
CD	$\frac{11,5}{10\times 50,0415}\times 1$	2,29

In alltestedsamples,the totalsugaramount(totalinvert)islowerorapproximatelyequalinrelationto thenatural invert, i.e., reducing sugars.

Table13:- Amount of acids(g/100g)inthetestedsamples.

Sample label	Calculation	Amountofacids(g/100g)
A1	100 250× ×1,2×0,1 25,0081×50	2,39
D1	100 250× ×1,33× 0,1 25,0010× 50	2,65
A2	100 250× ×1,0×0,1 25,0079×50	1,99
D2	100 250× ×1,13× 0,1 25,0066× 50	2,26
CA	100 250× ×1,23× 0,1 25,0132× 50	1,45
CD	100 250× ×1,06× 0,1 25,0122× 50	2,11

In relation to the cultivation method, the results show that the sample D2 (Dimentio hybrid) had themost total acids in the organic cultivation method, namely 2.65 g per 100 g of sample, then sampleA1(Amandavariety) 2.39 g per 100g ofsample,also in organicfarming.

Conclusion:-

According to the obtained results, we can conclude that there is a significant difference betweenplots under organic and conventional cultivation for most of the examined parameters of pepperfruit.Thephysicalandchemicalexaminationofthesoilcharacteristicsshowedanoptimalp Hofthe environment and a satisfactory amount of potassium, while other tested values were below theminimum.

After performing morphometric measurements of peppers, we can conclude that all morphometricpropertiesofpeppersarehigherin conventional cultivation, as expected.

The chemical properties results of the fruit show significantly higher concentrations of vitamin Cand sugar in conventional cultivation, while the number of acids in the pepper variety and hybridhadhighervalues in theorganic cultivation method.

Although soil properties for a certain method of production cannot be sufficiently improved duringone sowing season, to get a more realistic image of the impact of cultivation on the examinedparameters, especially in organic cultivation, research will be conducted next year at the samedynamics and determine the change of the morphometric properties and chemical composition ofpepperfruit.

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