2009 vol. 71, 111-121
DOI: 10.2478/v10032-009-0032-9

THE COMPARISON OF YIELDING AND NUTRITIVE VALUE OF ORGANIC AND CONVENTIONAL PEPPER FRUITS

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Received: August 6, 2009; Accepted: September 24, 2009

Summary

During 2006-2008 in Research Institute of Vegetable Crops at Skierniewice the studies were conducted on yielding and fruit quality of pepper cultivated by organic and conventional method. Two experiments were set on the nearby organic and conventional fields. The first one was conducted on the certified organic experimental field having red clover mixed with grasses as a fore-crop. Pest and disease control was provided according to organic standards. In conventionally managed field a mineral fertilization and chemical weed, pest and disease control was used. A fore crop for conventional pepper was a mixture of cereals with papilionaceous. In both experiments two kinds of field mulching was examined using fresh cut red clover and black polypropylene flees with no mulching for the control. The contents of vitamin C, β-carotene, soluble phenols and total flavonoides in matured fruits were examined.

The results revealed an impact of cultivation method and mulching on the yield and fruit quality of sweet pepper. In the first two years the conventional method was superior in respect of the total and marketable fruit yield. In the third year significantly better yielding was obtained from organic cultivation. The plants of conventional pepper suffered from soil borne diseases while organic plants showed good health conditions. Flees mulching increased the total yield of organic pepper, but the differences were significant in the last year only. Organic fruits distinguished themselves with the higher mean fruit weight, less wastes and more intensive redness as compared to conventional fruits. Chemical analysis revealed higher content of ascorbic acid, beta carotene, soluble phenols and total flavonoides in organic pepper as compared to conventional ones. Some beneficial effect of clover mulching on the content of ascorbic acid, β-carotene and soluble phenols irrespectively on the cultivation method was observed.

However the concentration of flavonoides was higher in fruits cultivated without mulching. Both examined mulching materials decreased amount of flavonoides in fruits irrespectively on cultivation method.

key words: pepper, organic cultivation, fruit quality, antioxidants

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INTRODUCTION

A high and good quality yield is required for the success of organic production. In general opinion organic vegetables yield by 30% lower than conventional ones. One of the basic reasons for lower yielding is insufficient fertilizer availability, particularly nitrogen approach. Soil organic matter after humification and mineralization can be a source of nitrogen. In this farming system soil serves as reservoir and transformer of nutrients for crop productivity. An overall objective of organic production is to increase the chemical, physical and biological soil fertility. The more stabilised soil environment the better crop productivity. In the long term studies conducted by Mac Rae *et al.* (2006) during the first years after conversion the yield of organic vegetables was by 40% lower than conventional ones. As the soil fertility and biodiversity built up, 5-10 years after conversion the differences significantly diminished.

Organic vegetables are recognised as a better health product, because of no pesticide residues and higher vitamins and antioxidants contents. More vitamin C, flavonoides and luteine in organic pepper found Hallmann *et al*. (2005). Likewise Szafirowska & Elkner (2008) obtained higher content of vitamin C and flavonoides in several cultivars of organic pepper .

A nutrition value of vegetables depends on weather conditions. The small rainfalls and low air humidity have a beneficial impact on vitamin C content . This was proved for tomatoes and onion (Elkner 1991, Franczuk 2000).

The method of cultivation and fertilization are also of some importance. The adverse effect of nitrate and potassium surplus caused a decline of sugars and vitamin C content in carrot roots (Michalik 1985), tomatoes (Davies & Winsor 1968, Elkner 1991), and brassicas (Jabłońska-Ceglarek 1981). On the other hand organic manures are known for their beneficial influence on nutrition value of vegetables. Elkner and Rumpel (1995) observed an increase of sugars and vitamin C and the decrease of nitrate nitrogen in vegetables cultivated on farm manure. Similarly Jabłońska-Ceglarek *et al*. (2000) and Wójcik-Wojtkowiak *et al.* (2000) noticed higher concentration of vitamin C in cabbage, onion and red pepper cultivated on farm and green manure.

The aim of research focused on yielding and nutritive value of sweet pepper produced by organic and conventional method with or without row mulching.

MATERIALS AND METHODS

The studies were performed in Research Institute of Vegetable Crops at Skierniewice during 2006-2008. Two parallel experiments were set on organic and conventional nearby fields on sandy loam soil with pH 6.0-6.5. Each field experiment was arranged as a randomized block design with 4 replications. The plot size was 5.5 m long and 1.35 m wide with 45 cm spacing between rows, and 40 cm between plants. A three row strip system of pepper cv. Roberta F_1 planting was used. In both experiments two kind of surface mulching was ap-

plied: fresh cut clover or black polypropylene flees P-50 (50 $g \cdot m^{-2}$). The control plots were not mulched. Each year the transplants were planted at the beginning of June. In organically managed pepper a 6 year crop rotation was used, having red clover mixed with grasses as a fore-crop. Once a year a foliar application of 0.2% Bio-Algeen (algs extract) was provided. For disease control the grapefruit extract was used as a preventive measure. In conventionally managed field a 3 year crop rotation was applied having a mixture of cereals with papilionaceous as a fore-crop. A mineral fertilization according to soil analysis was used with ammonium nitrate applied as a top-dressing (50 $kg \cdot ha^{-1}$). Once or twice in the season 0.7% calcium nitrate solution against dry-rot was applied. In 2007 a chemical treatment was applied against soil born diseases occurred on conventional field. In 2008 newly transplanted pepper showed retardation of rooting and growth, thus delaying crop development. Besides, some plants were attacked by verticillium wilt. For the plant recover the additional leave fertilizers were applied. In both years the chemical control against aphids was provided. In 2006 the fruits were harvested 5 times, an in the next two years 4 times only on both organic and conventional field. The fruit yield was determined according to European Commission Regulation No 1455/1999 and separated for marketable, undeveloped and diseased crop. The two first harvests were counted as an early crop.

For morphological and chemical analysis 30 ripe fruits from each plot were taken.

Each fruit weight excluding waste parts as well as the color indicators were examined according to the Hunter Lab scale using ("a" for redness, „b" for yellowness). The contents of following chemicals were determined: ascorbic acid by Tillman's method (according to PN-90A-75101/07), β-carotene by adsorption column chromatography (Davis *et al.* 1970), total flavonoides by colorimetric method according to Zhishen *et al.* (1999) and soluble phenols by colorimetric method with the use of Folin-Ciocalteu reagent (Ragazzi & Veronese 1973).

The results were statistically analysed by ANOVA and the significance between treatment means were compared with Newman-Keul's test at the level of significance P=0.05.

RESULTS AND DISCUSSION

Weather conditions in respect of temperature and rainfalls varied between years of research. In 2006 the drought with a high temperature especially in July hasten the plant development thus decreasing number and mean weight of fruits. In 2007 and 2008 average monthly temperature was lower with a higher rainfalls in August. Organically managed pepper matured by 7-10 days later and produced smaller early yield especially in first two years (Table 1). Both examined factors the cultivation method as well as mulching affected the height and the structure of the yield (Table 2). In the first year organic pepper plants yielded worse than conventional ones and produced significantly lower marketable and total yield of fruits. The mean total yield of organic pepper was 18.4 kg

as compared to 36.8 kg·10 m^{-2} in conventional method. In remaining years related amounts were 25.9 kg compared to 27.7 kg, and 27.9 to 20.6 kg·10 m^{-2}. In 2008 organic pepper yielded distinctly better than conventional. Plots mulched with clover and flees produced significantly higher yield of organic pepper than conventional. Lower yielding of conventional pepper in last two years was due to soil-borne diseases caused by *Rhizoctonia solani i Fusarium annum* occurrence on conventional field only. In addition in 2008 some problems with the transplant rooting, aphids feeding and fruit molding were observed on conventional field.

Table 1. The effect of cultivation method and row mulching on early yield of pepper cv. Roberta F_1

Cultivation method	Mulching	Early yield kg·10m $^{-2}$			Number of fruits per plant		
		2006	2007	2008	2006	2007	2008
Organic	Control	4.5	8.4	9.0 b	1.5	3.1	3.3
	Clover	6.7	6.9	15.6 ab	1.8	2.7	4.0
	Flees	7.4	7.2	19.1 a	2.3	2.4	4.9
	Mean	6.2 b	7.5 b	14.6	1.9	2.7 b	3.8
Conventional	Control	8.8	11.5	12.5 ab	3.5	4.9	4.8
	Clover	10.3	9.4	11.1 ab	3.4	3.5	4.5
	Flees	11.9	10.4	9.4 b	3.9	4.7	3.4
	Mean	10.3 a	10.4 a	11.0	3.6	4.4 a	4.2

Note: Numbers followed by the same letter do not differ significantly at P=0.05

Table 2. The effect of cultivation method and mulching on the yield structure of pepper

Cultivation method	Mulching	Marketable yield			Diseased fruits			Total yield		
		kg·10 m^{-2}								
		2006	2007	2008	2006	2007	2008	2006	2007	2008
Organic	Control	17.1b	23.6	18.8b	3.7	1.0	3.8	20.8b	24.6	22.6ab
	Clover	14.8 b	24.9	25.9ab	2.1	0.9	4.8	16.9b	25.8	30.7a
	Flees	18.2 b	26.5	26.7a	2.5	0.6	3.6	20.7b	27.1	30.3a
	Mean	16.7	25.0	29.5	2.8	0.9	4.1	18.4	25.9	27.9
Conventional	Control	29.5ab	29.9	20.4ab	3.0	0.4	1.4	32.5ab	29.3	21.8b
	Clover	37.4a	25.1	17.7b	3.4	1.1	1.9	40.8a	26.2	19.6b
	Flees	33.4a	26.6	17.6b	3.3	0.8	2.7	36.7ab	27.4	20.3b
	Mean	33.4	27.2	18.5	3.2	0.8	2.1	36.8	27.7	20.6

Note: see Table 1

According to Buczkowska & Bednarek (2005) sweet pepper output highly depends on temperature regime. The average yield of red pepper cv. Roberta F_1 in conventional production varied from 2.79 to 3.68 kg·m^{-2}. The gradual progress of the pepper yield in discussed paper is likely connected with the soil fertility and viability stabilization. This fact as well as a longer crop

rotation period in organic experiment seem to affect the crop results. In the USA experiment, Clark (1999) found a gradual increase of tomato yield as the time from conversion period extended. During 3 years after conversion the organic tomato produced lower yield than conventional, but after next 5 years the yield of organic tomatoes reached 80 t·ha^{-1} comparing to 68 t for conventional method. Other authors revealed that organic vegetables manage better under unfavourable conditions (Ching 2001). Row mulching contributed to the yield structure improvement and to the increase of marketable crop, although just a tendency not the significant differences were noticed. The mulched plants produced bigger fruits of more intensive colour with less wastes (Table 2 & 3).

Table 3. The influence of cultivation method and mulching on some morphological characters of organic and conventional pepper fruits. Average from 3 years

Cultivation method	Mulching	Fruit mass (g)	Waste (g)	Fruit color	
				Redness (a)	Yellowness (b)
Organic	Control	146.3	14.3	25.3	8.8
	Clover	175.7	12.0	26.5	8.6
	Flees	169.0	11.7	27.9	9.4
	Mean for method	163.7 a	12.7	26.6	8.9 b
Conventional	Control	130.3	15.0	24.8	9.4
	Clover	134.3	12.3	26.7	9.1
	Flees	142.7	11.7	28.7	9.9
	Mean for method	135.8 b	13.0	26.8	9.5 a
Mean value for control		138.3	14.7 a	25.1 b	9.1 ab
Mean value for clover		155.0	12.2 b	26.6 ab	8.8 b
Mean value for flees		156.8	11.7 b	28.3 a	9.6 a

Note: see Table 1

The main health protective components of red pepper fruits are vitamins and polyphenols (Kaur & Kapoor 2002, Perucka & Materska 2007). In our experiment the examined factors as well as the weather conditions affected the amount of mentioned components. In 2006 the pepper fruits comprised the highest amount of vitamin C with the average value 229 mg·100 g^{-1} (Fig. 1). In the next years cool and more rainy weather delayed fruit maturity and restricted vitamin C content down to 191 mg·100 g^{-1} in 2007 and 165 mg·100 g^{-1} in 2008. However during the whole experiment period organic pepper contained more vitamin C than conventional. Similar tendency of higher vitamin C content in organic tomatoes observed Asami *et al.* (2003), in onion cultivars Hallmann & Rembiałkowska (2007) and in several pepper cultivars Szafirowska & Elkner (2008). Earlier studies of Pither & Hall (1990) also revealed more vitamin C in organic than conventional cabbage and apples. The influence of mulching on vitamin C content in pepper fruits was significant though varied in years. The fruits harvested from plots mulched with black flees exhibited the lowest concentration of vitamin C irrespectively on the cultivation method. However the

statistical analysis of means from three years of research revealed insignificant influence of mulching on vitamin C level in pepper fruits.

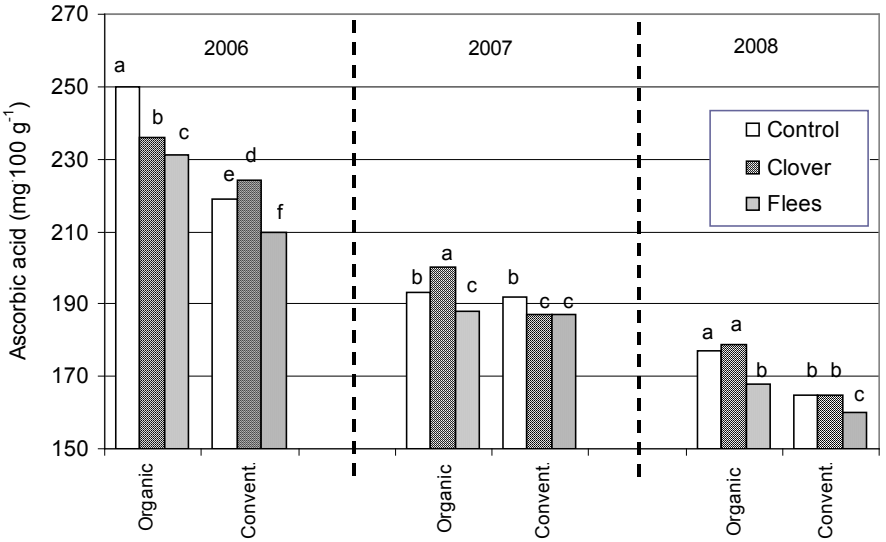


Fig. 1. Influence of cultivation system (A) and mulching (B) on ascorbic acid content in pepper fruits from organic and conventional cultivation in 2006-2008

β-carotene content in fruits of organic pepper was higher than in conventional ones and it was true for each year of research (Fig. 2). It is in agreement with the earlier studies of Szafirowska & Elkner (2008) which revealed higher β-carotene contain in the fruits of three organically managed pepper cultivars as compared to conventional cultivation. Pither & Hall (1990) and Rembiałkowska *et al.* (2003) examined a nutrition value of tomatoes from organic and conventional farms, and found more β-carotene in organic tomato fruits. Mulching significantly affected β-carotene content irrespectively on cultivation method in 2006 and 2008. In the mentioned years clover mulching increased β- carotene content especially in organic cultivation. Instead the black flees decreased beta carotene content irrespectively on cultivation method.

Organic pepper contained more total flavonoides and soluble phenols than conventional ones (Fig. 3 & 4). It is in agreement with the earlier studies concerning pepper (Szafirowska & Elkner 2008), tomato (Rembiałkowska *et al.* 2003) and onion (Hallmann & Rembiałkowska 2007). A distinct influence of mulching on soluble phenols content in pepper fruits was obtained (Fig. 3). In organic cultivation the highest content of phenols exhibited fruits from plots mulched by cut clover, whereas in conventional management from the plots with no mulching.

Negative effect of mulching on flavonoides content was observed irrespectively on cultivation method.

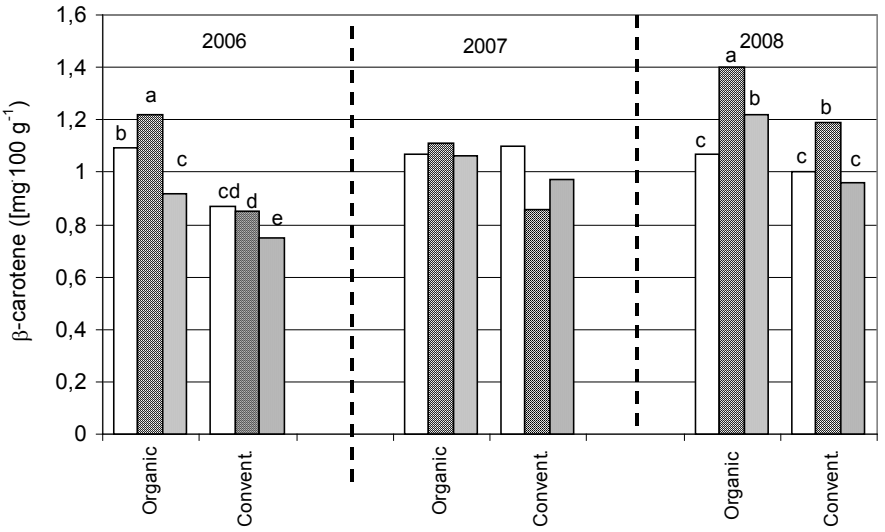


Fig. 2. Influence of cultivation system (A) and mulching (B) on total b-carotene content in pepper fruits from organic and conventional cultivation in 2006-2008

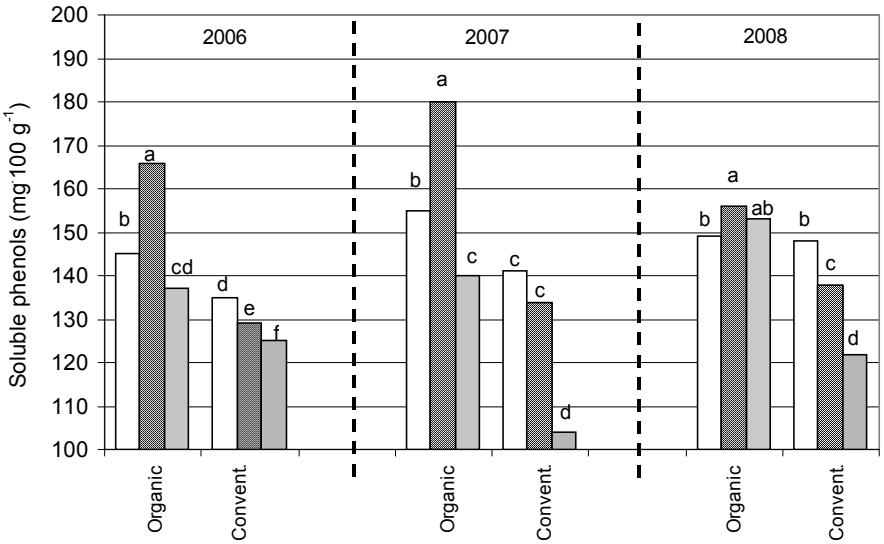


Fig. 3. Influence of cultivation system (A) and mulching (B) on soluble phenols content in pepper fruits from organic and conventional cultivation in 2006-2008

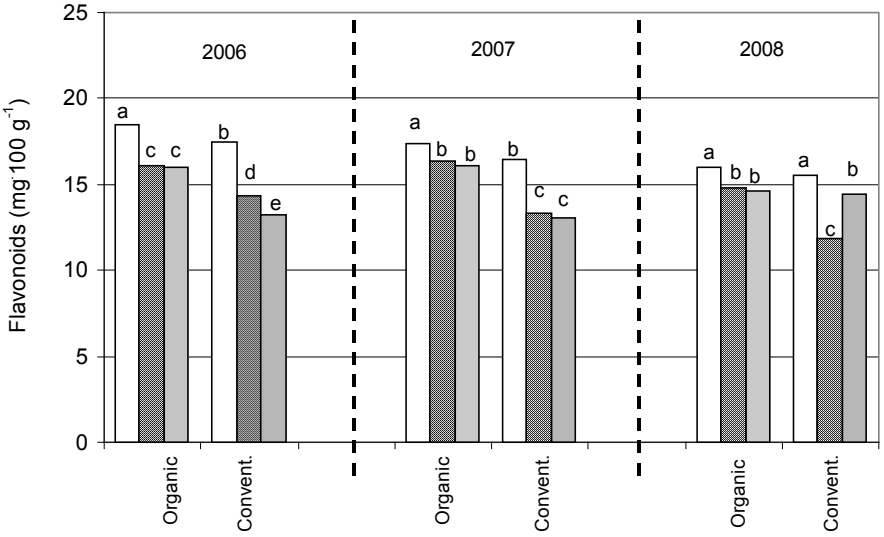


Fig. 4. Influence of cultivation system (A) and mulching (B) on total flavonoids content in pepper fruits from organic and conventional cultivation in 2006-2008

According to Lee & Howard (1995) and Szafirowska & Elkner (2008) polyphenols synthesis in pepper fruits depend mainly on a variety, harvest term and weather conditions. Therefore many authors noticed differences in their concentration in dependence on the year (Vinson *et al.* 1998, Szafirowska & Elkner 2008). A distinct variations in total flavonoides, soluble phenols, β-carotene and particularly in vitamin C content in dependence on the year occurred also between treatments in the discussed studies.

The most favourable conditions for vitamin C and total flavonoides content in pepper fruits prevailed in 2006, but for β-carotene and soluble phenols more beneficial were 2007 and 2008. However the concentration of mentioned compounds was significantly higher in organic than conventional pepper in each year.

CONCLUSION

1. A three years research revealed an impact of cultivation method and mulching on the yield and fruit quality of sweet pepper cv. Roberta F_1.
2. In the first two years the conventional method was superior in respect of the total and marketable fruit yield. However in the third year significantly better yielding was obtained from organic cultivation.
3. Flees mulching increased the total yield of organic pepper, but the differences were significant in the last year of studies.
4. Organic fruits distinguished themselves with the higher mean fruit weight, less wastes and more intensive redness as compared to conventional fruits.
5. Organic pepper contained more ascorbic acid, β-carotene, soluble phenols and total flavonoides.

6. There was stated a beneficial effect of clover mulching on the content of ascorbic acid, β-carotene and soluble phenols irrespectively to the cultivation method. However the plants of mulched plots developed fruits of lower flavonoids concentration irrespectively on the growing method. The highest level of mentioned compounds was indicated in the fruits from the mulch less control.

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PORÓWNANIE PLONOWANIA I WARTOŚCI BIOLOGICZNEJ OWOCÓW PAPRYKI Z UPRAWY EKOLOGICZNEJ I KONWENCJONALNEJ

Streszczenie

W latach 2006-2008 w Instytucie Warzywnictwa w Skierniewicach prowadzono badania nad oceną plonowania i jakości papryki słodkiej odm. Roberta F_1 uprawianej dwiema metodami: ekologiczną i konwencjonalną. Założono dwa doświadczenia na sąsiadujących ze sobą polach. Pierwsze doświadczenie prowadzono na certyfikowanym polu doświadczalnym, gdzie paprykę uprawiano po mieszance koniczyny z trawami. Ochronę przed szkodnikami i chorobami prowadzono zgodnie ze standardami dla upraw ekologicznych. W drugim doświadczeniu prowadzono uprawę w sposób konwencjonalny, w którym paprykę sadzono po mieszance zbóż z motylkowatymi. Stosowano wyłącznie nawożenie mineralne oraz pestycydy do ochrony roślin przed chwastami, chorobami i szkodnikami. Drugim badanym czynnikiem było mulczowanie międzyrzędzi czarną agrowłókniną lub świeżo ściętą koniczyną w obu systemach uprawy. Kontrolę stanowiły obiekty nie mulczowane. W fazie dojrzałości zbiorczej wykonano analizy chemiczne owoców pod kątem zawartości witaminy C, beta karotenu, rozpuszczalnych fenoli oraz flawonoidów ogółem. Stwierdzono wpływ metody uprawy oraz

mulczowania poletek na plon i jakość owoców papryki słodkiej. W dwóch pierwszych latach lepsze wyniki uzyskano z uprawy konwencjonalnej, jeśli chodzi o plon całkowity i handlowy. W trzecim roku badań istotnie wyższe plonowanie stwierdzono w uprawie ekologicznej. Przyczyną gorszego plonowania papryki w uprawie konwencjonalnej było słabe ukorzenianie się roślin po posadzeniu rozsady oraz wystąpienie chorób odglebowych. Zastosowanie czarnej agrowłókniny zwiększyło plon całkowity owoców przy czym istotność różnic wykazano tylko w ostatnim roku. Owoce z uprawy ekologicznej charakteryzowały się większą średnią masą owocu, mniejszą masą łożyska i lepszym wybarwieniem (czerwoność). Ponadto papryka uprawiana w sposób ekologiczny zawierała więcej witaminy C, β-karotenu, rozpuszczalnych fenoli i flawonoidów ogółem w porównaniu do papryki konwencjonalnej. Stwierdzono korzystny wpływ ściółkowania poletek ściętą koniczyną na wzrost zawartości w papryce kwasu askorbinowego, β-karotenu i fenoli rozpuszczalnych niezależnie od systemu uprawy. Natomiast poziom zawartości flawonoidów był najwyższy w owocach z roślin z poletek kontrolnych, a ściółkowanie ściętą koniczyną lub włókniną obniżało ich zawartość w obydwu systemach uprawy.