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THE EFFECT OF INTERCROPPING ON YIELDING OF ROOT VEGETABLES OF *Apiaceae* FAMILY

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Abstract. Intercropping of vegetables is experiencing a renaissance with the uptake of organic farming. Cultivation of several plant species simultaneously eliminates negative traits of homogenous cultivation, supports bio-diversity and remains compliant with the rule of balanced agriculture. Carrot and root parsley are two vegetables that have very high requirements towards the conditions of growth. Their cultivation together with other species is a conscious introduction of competitive plants, therefore it was interesting to observe their reaction to intercropping. Among various combinations of compared cultivation types, intercropping with onion turned out to be most beneficial to both carrot and parsley. The ones cultivated together with onion created the highest yield of marketable roots, total yield and yield of leaves. Onion growing next to them had positive effect on the structure of root yield, especially in case of carrot, increasing commercial root share. Intercropping of carrot and parsley with marigold had unfavorable effect on yielding and growth of these vegetables. Intercropping did not affect the number of carrot and parsley emergence, nor yield of fine roots. Total marketable yield of root vegetables obtained from intercropping with onion was greater than that from homogenous cultivation. The effect of intercropping of carrot with parsley was modified by a year of research.

Key words: homogenous cultivation, carrot, parsley, marigold, onion, yield

INTRODUCTION

The cultivation of the same species or even the same variety on multi-hectare surfaces has negative effects and is not in accordance with nature. Natural plant communities consist of many plant species which are connected with one another with a net of mutual dependencies and influences. They create a habitat for existence of useful species of insects and microorganisms [Legutowska et al. 2001, Dhimmar 2009, Wiech et al. 2009]. Cultivation of one species leads to increased existence of pathogens and pests

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[Uvah and Coaker 1984, Theunissen et al. 1995, Mateeva et al. 2002]. They cause one-sided nutrient exhaustion in soil.

Cultivation of several plant species side by side removes negative traits of a monoculture and therefore is commonly used in biodynamic gardens. This kind of cultivation is pro ecological; it supports bio-diversity and is compliant with the rules of balanced agriculture [Wiech and Kałmuk 2005, Suresha et al. 2007, Ouma and Jeruto 2010]. Intercropping of vegetables is no novelty, yet in recent years, along with popularity of organic farming, it is being discovered again [Osiru 1983, Ouma and Jeruto 2010]. In spring time, intercropping of vegetables is frequently applied in order to economically use areas under roof and obtain yield from several species in short time differences. This method is used less in field cultivation of vegetables because it is more labor-consuming [Ogbuehil and Orzolek 1987].

Carrot and root parsley are of great importance in both commercial and private cultivation. Both these species have high requirements for conditions of growth, in terms of climate and soil [Błażewicz-Woźniak 1998, 2004, Whalley et al. 2004]. Their cultivation alongside other species is a conscious introduction of competitive plants, therefore it was interesting to see their reaction to intercropping. The purpose of the conducted research was to define the effect of intercropping on the yielding of carrot and root parsley.

MATERIAL AND METHODS

The field experiment was conducted in years 2004–2006 in Felin Experimental Station of the University of Life Sciences in Lublin (51°14' N and 22°32' E), on a grey-brown podzolic soil developed from loess soil deposited on chalky marls. In terms of their mechanical composition, this is a medium silty loam. Carrot 'Perfekcja' and root parsley 'Berlińska' were used as experimental plants. The experimental facilities were as follows: 1. Control – homogenous cultivation, 2. Intercropping of carrot with parsley, 3. Intercropping with onion 'Wolska', 4. Intercropping with *Tagetes patula* L. *nana* fl.pl. The experiment was established by means of the method of completely randomized blocks in 4 replications. The surface area of 1 plot equaled 4.5 m^2, for harvest – 3.6 m^2.

The forecrop for the vegetables was wheat. Tillage included deep ploughing before winter, with harrowing in spring, followed by cultivating and finishing tillage. Mineral nutrition was applied in spring in the following amount: 35 kg of $P \cdot ha^{-1}$ in the form of superphosphate, 160 kg of $K \cdot ha^{-1}$ in the form of KCl and 100 kg of $N \cdot ha^{-1}$ in the form of ammonium nitrate in two doses (½ before sowing and ½ after sowing). Sowing of all species took place at the same time every year (April 27th) in the norm of 6 $kg \cdot ha^{-1}$. In the fields with intercropping, seeds of carrot, parsley, onion and marigold were sowed alongside each other in rows every 30 cm. During vegetation manual weeding was performed 4–5 times a year. Number of emerged plants per 1 m^{-1} was noted. Onion was harvested on August 15th, whereas carrot and parsley – on October 1st. Total yield and commercial yield of carrot and parsley were noted, as well as structure of yield including commercial [EKG/ONZ FFV-10], fine and misshapen roots (infected and branched).

Table 1. Mean monthly air temperatures and amount of precipitation in ES Felin in years 2004–2006

Tabela 1. Średnie miesięczne temperatury powietrza i sumy opadów w GD Felin w latach 2004–2006

	Year – Rok	Month – Miesiąc					
		IV	V	VI	VII	VIII	IX
Temperature Temperatura °C	2004	7.9	11.9	15.8	18.1	18.3	12.8
	2005	9.1	13.2	16.0	19.8	16.9	14.9
	2006	8.7	13.6	16.9	21.9	17.4	15.7
	mean for 1951–2000 średnio z lat	7.5	13.0	16.5	17.9	17.3	12.9
Amount of precipitation Suma opadów mm	2004	38.1	38.0	49.9	90.5	48.5	14.2
	2005	18.6	98.0	55.9	109.8	108.7	18.0
	2006	30.3	59.5	37.9	6.8	132.6	11.0
	mean for 1951–2000 średnio z lat	40.6	58.3	65.8	78.0	69.7	52.1

Also the yield of carrot and parsley leaves was noted and total and commercial yield of onion [EKG/ONZ FFV-25]. The obtained results were statistically elaborated, by means of variance analysis. The significant differences were checked using Tukey's test, at $p = 0.05$. The weather conditions during the vegetables cultivation period are shown in table 1.

RESULTS

The total yield of carrot roots in the period 2004–2006 was average on 5.54 kg m^{-2} and stayed within the range of 3.89 to 7.65 kg m^{-2} (tab. 2). Carrot cultivated with onion (MC) produced best yield. In such combination, average of 6.48 kg m^{-2} of carrot roots was harvested. Also root parsley turned out to be good neighborhood for carrot. The yield of carrot roots in intercropping with parsley (MP) was higher than yield in pure sowing (MM) by average 1.04 kg on 1 m^{-2}. The lowest yield resulted from cultivation with marigold (average 4.35 kg m^{-2}). These dependencies repeated throughout the research period. The highest carrot yield was harvested in 2006 and the lowest in 2004.

Intercropping had significant effect on commercial yield of carrot roots. The average yield in the period 2004–2006 was 3.51 kg m^{-2} and depending on the year and particular combination of cultivation it reached value between 2.38 and 4.93 kg m^{-2} (tab. 2). Cultivation with onion had beneficial effect on the size of marketable yield of carrot. In this combination (MC) more commercial roots were harvested (average 4.36 kg m^{-2}). Proximity of parsley (MP) only slightly increased marketable yield of roots in comparison to homogenous cultivation (MM). The influence of marigold on the size of commercial yield of carrot (MA) was very negative. Only 2.59 kg of marketable roots from 1 m^2 was obtained. Throughout the research period the size of commercial yield of carrot was similar and there were no significant differences.

Table 2. Total and marketable yield of roots of carrot and parsley grown in intercropping in years 2004–2006

Tabela 2. Plon korzeni ogółem i plon handlowy marchwi i pietruszki w uprawie współrzędnej w latach 2004–2006

Experimental plant Roślina doświadczalna	Combination Kombinacja	Total yield of roots in kg m^{-2} Plon ogółem korzeni				Marketable yield of roots in kg m^{-2} Plon handlowy korzeni			
		2004	2005	2006	mean średnia	2004	2005	2006	mean średnia
Carrot – Marchew	MM	4.78	4.47	6.18	5.14	3.05	3.05	3.59	3.23
	MP	4.82	6.41	7.31	6.18	2.81	4.39	4.38	3.86
	MC	5.84	5.96	7.65	6.48	4.11	4.03	4.93	4.36
	MA	4.27	3.89	4.89	4.35	2.81	2.38	2.57	2.59
	mean – średnia	4.93	5.18	6.51	5.54	3.20	3.46	3.87	3.51
$LSD_{0.05}$ for – $NIR_{0,05}$ dla:									
Combination – Kombinacji					1.41				1.05
Years – Lat					1.11				n.s.
Parsley – Pietruszka	PP	2.84	5.36	2.64	3.61	1.30	2.15	0.85	1.43
	PM	2.85	5.79	3.05	3.90	0.74	2.01	0.99	1.25
	PC	4.23	8.54	3.58	5.45	1.40	3.50	1.44	2.11
	PA	2.29	3.30	2.08	2.56	0.75	1.08	0.51	0.78
	mean – średnia	3.05	5.75	2.84	3.88	1.05	2.19	0.95	1.39
$LSD_{0.05}$ for – $NIR_{0,05}$ dla:									
Combination – Kombinacji					1.02				0.61
Years – Lat					0.80				0.48

MM – carrot – marchew; MP(PM) – carrot + parsley – marchew + pietruszka, MC – carrot + onion – marchew + cebula, MA – carrot + marigold – marchew + aksamitka, PP – parsley – pietruszka, PC – parsley + onion – pietruszka + cebula, PA – parsley + marigold – pietruszka + aksamitka; n.s. – no significant differences – różnice nieistotne statystycznie

Yield of fine and non-commercial roots did not depend significantly on the combination of cultivation and were modified only by years of research (tab. 3.) However, throughout the period of experience a tendency was noted, that the larger quantity of fine roots was harvested from the combination where carrot grew alongside parsley (MP), and the less when cultivated alongside marigold (MA). It was also observed that in cultivation with marigold (MA), yield of infected or misshapen roots in comparison to cultivation of carrot with onion (MC) was decreased.

Yield of parsley roots throughout the 3-year research period equaled average of 3.88 kg m^{-2} and ranged from 2.08 to 8.54 kg m^{-2} (tab. 2). The highest yield was harvested from cultivation of parsley alongside onion (average 5.45 kg m^{-2}), and the lowest from cultivation with marigold (2.56 kg m^{-2}) (PA). In 2005 parsley yield was almost twice higher than in 2006.

Marketable yield of parsley roots was average of 1.39 kg m^{-2} (from 0.51 to 3.50 kg m^{-2}) and was significantly modified by combination of cultivation and research years (tab. 2). As in case of carrot, also for the size of commercial yield of parsley, cultivation

alongside onion (PC) had beneficial effect. Average of 2.11 kg m^{-2} of marketable roots was obtained. However, unlike carrot, parsley produced better yield in pure sowing (PP) than when cultivated in neighborhood of carrot (PM). Cultivation of parsley with marigold (PA) had significantly negative effect on the size of commercial yield of roots. Only 0.78 kg of marketable roots of parsley was harvested from 1 m^2.

Table 3. Yield of fine and unmarketable (infected and misshaped) roots of carrot and parsley grown in intercropping in years 2004–2006

Tabela 3. Plon korzeni drobnych i niehandlowych (chorych i niekształtnych) marchwi i pietruszki w uprawie współrzędnej w latach 2004–2006

Experimental plant Roślina doświadczalna	Combination Kombinacja	Yield of fine roots Plon korzeni drobnych kg m^{-2}				Unmarketable yield of roots Plon korzenie niehandlowych kg m^{-2}			
		2004	2005	2006	mean średnia	2004	2005	2006	mean średnia
Carrot – Marchew	MM	0.90	1.11	1.78	1.26	0.83	0.31	0.81	0.65
	MP	1.20	1.56	1.82	1.53	0.81	0.46	1.11	0.79
	MC	0.76	1.18	1.72	1.22	0.97	0.75	1.00	0.91
	MA	0.81	1.14	1.52	1.16	0.65	0.37	0.80	0.61
	mean – średnia	0.92	1.25	1.71	1.29	0.82	0.47	0.93	0.74
$LSD_{0.05}$ for – $NIR_{0,05}$ dla: Combination – Kombinacji					n.s.				n.s.
Years – Lat					0.38				0.28
Parsley – Pietruszka	PP	0.44	0.72	0.68	0.61	1.10	2.49	1.11	1.57
	PM	0.48	0.93	0.60	0.67	1.63	2.85	1.46	1.98
	PC	0.57	0.94	0.51	0.67	2.26	4.10	1.63	2.66
	PA	0.42	0.61	0.55	0.53	1.12	1.61	1.02	1.25
	mean – średnia	0.48	0.80	0.59	0.62	1.53	2.76	1.31	1.87
$LSD_{0.05}$ for – $NIR_{0,05}$ dla: Combination – Kombinacji					n.s.				0.57
Years – Lat					0.21				0.45

MM – carrot/marchew; MP(PM) – carrot+parsley/marchew+pietruszka, MC – carrot+ onion/marchew+ cebula, MA – carrot+marigold/marchew+aksamitka, PP – parsley/pietruszka, PC – parsley+onion/pietruszka+cebula, PA – parsley+marigold/pietruszka+aksamitka; n.s. – no significant differences/różnice nieistotne statystycznie

Intercropping did not affect the size of yield of parsley fine roots. Differences appeared only between particular years of experience (tab. 3). In combination with onion (PC), parsley produced most non-commercial roots (average 2.66 kg m^{-2}). The fewest infected and misshapen roots were harvested annually from cultivation with marigold (PA) (average 1.25 kg).

In the yield structure of carrot roots marketable yield equaled 63% on average (fig. 1). Cultivation alongside onion (MC) increased commercial roots share in the yield up to 67.2%, while in cultivation with marigold (MA) it was only 59.5%. Yield structure of carrot in pure sowing (MM) and in cultivation with parsley (MP) were similar.

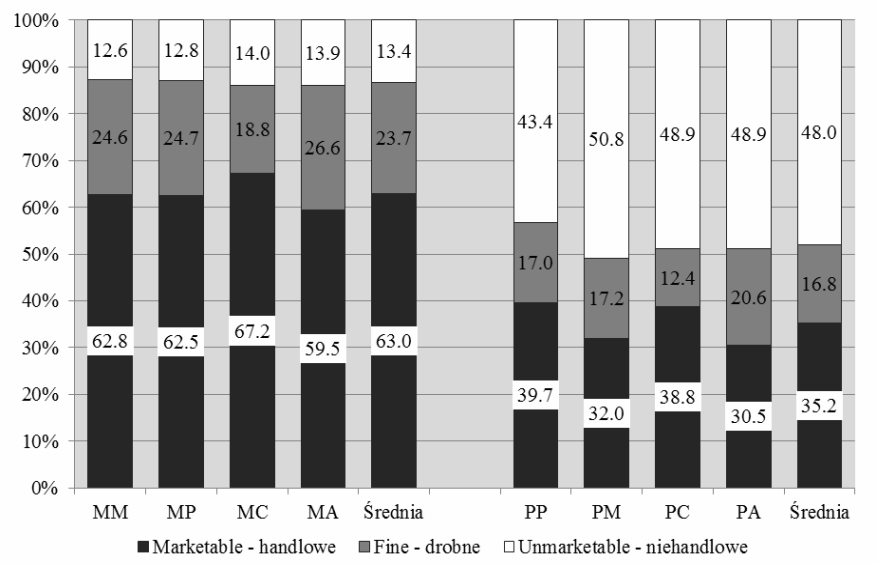
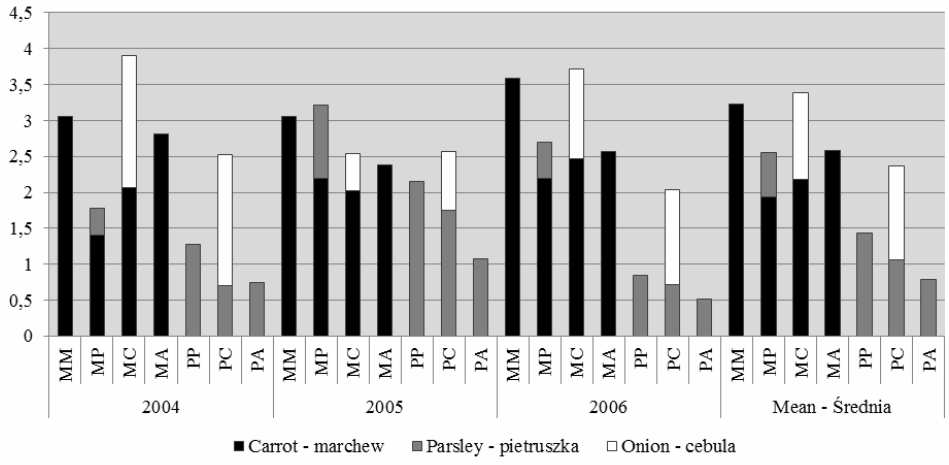


Fig. 1. The structure of root yield of carrot and parsley, depending on the combination of intercropping in years 2004–2006

Rys. 1. Struktura plonu korzeni marchwi i pietruszki w zależności od kombinacji uprawy współrzędnej w latach 2004–2006



$LSD_{0.05}$ for – $NIR_{0,05}$ dla:	
Combination – Kombinacji A	0.75
Years – Lat B	n.s.
A × B	1.59

Fig. 2. Total marketable yield of vegetables in kg m^{-2} depending on the combination of intercropping in years 2004–2006

Rys. 2. Całkowity plon handlowy warzyw w kg m^{-2} w zależności od kombinacji uprawy współrzędnej w latach 2004–2006

Commercial roots comprised merely 35.2% of total yield of parsley (fig.1). Parsley produced best yield in pure sowing. In cultivation without other species (PP) marketable roots share in total yield of parsley was largest (average 39.7%). Parsley responded relatively well to the cultivation with onion (PC) – 38.8% of marketable yield was produced. Cultivation with carrot (PM) increased share of non-commercial roots in total parsley yield up to 50.8%, whereas cultivation with marigold (PA) decreased commercial yield down to 30.5% and increased share of small roots (up to 20.6%).

Table 4. Emergence and yield of leaves of carrot and parsley grown in intercropping in years 2004–2006

Tabela 4. Wschody i plon liści marchwi i pietruszki w uprawie współrzędnej w latach 2004–2006

Experimental plant Roślina doświadczalna	Combination Kombinacja	Emergence in No m^{-1} Wschody w szt. m^{-1}				Yield of leaves in kg m^{-2} Plon liści			
		2004	2005	2006	mean średnia	2004	2005	2006	mean średnia
Carrot – Marchew	MM	82.8	60.5	54.5	65.9	0.85	0.72	1.10	0.89
	MP	66.5	76.0	46.8	63.1	0.80	0.88	1.35	1.01
	MC	66.5	49.8	48.3	54.8	1.08	0.96	1.21	1.08
	MA	68.5	47.5	34.3	50.1	0.56	0.48	0.88	0.64
	mean – średnia	71.1	58.4	45.9	58.5	0.82	0.76	1.13	0.90
$LSD_{0.05}$ for – $NIR_{0,05}$ dla:									
Combination – Kombinacji					n.s.				0.19
Years – Lat					16.4				0.25
Parsley – Pietruszka	PP	87.8	103.3	41.0	77.3	1.88	2.90	1.69	2.16
	PM	82.3	100.5	33.8	72.2	1.67	2.65	1.79	2.04
	PC	64.0	76.8	44.5	61.8	2.54	5.79	2.46	3.60
	PA	94.3	81.5	33.0	69.6	1.51	2.28	1.34	1.71
	mean – średnia	82.1	90.5	38.1	70.2	1.90	3.41	1.82	2.38
$LSD_{0.05}$ for – $NIR_{0,05}$ dla:									
Combination – Kombinacji					n.s.				0.67
Years – Lat					19.8				0.53

MM – carrot – marchew; MP(PM) – carrot + parsley – marchew + pietruszka, MC – carrot + onion – marchew + cebula, MA – carrot + marigold – marchew + aksamitka, PP – parsley – pietruszka, PC – parsley + onion – pietruszka + cebula, PA – parsley + marigold – pietruszka + aksamitka; n.s. – no significant differences – różnice nieistotne statystycznie

The total marketable yield of vegetables obtained from the tested combinations of carrot and parsley cultivation differed significantly (fig. 2). On the average, after the 3-year research period, the highest vegetable yield was harvested from intercropping of carrot with onion (MC) (3.38 kg m^{-2}). From homogenous cultivation of carrot (MM) only about 0.15 kg less commercial yield was obtained. Certainly, the lowest yield was produced in case of intercropping of parsley with marigold (PA). In this combination, average 0.78 kg of commercial yield was harvested. Cultivation of parsley with onion (PC) increased total yield of vegetables obtained in this combination up to average

2.38 kg m^{-2}, including yield of parsley root to 1.06 kg. Slight differences were noted between the years of experience. In 2004 and 2006 the highest total marketable yield was obtained from intercropping of carrot and onion (MC), and in 2004 was marked by a large share of the crop of onions. While in 2005 cultivation of carrot with parsley (MP) turned out to be most beneficial. In this combination, total of 3.21 kg of marketable roots was harvested.

Intercropping did not significantly affect the number of carrot and parsley emergence (tab. 4). Significant differences were noted only between the research years. Carrot emergence were the best in 2004 and parsley in 2005. Application of intercropping affected yield of leaves of both tested vegetables (tab. 4). Both carrot and parsley produced greatest mass of leaves in intercropping with onion (1.08 and 3.60 kg m^{-2} respectively). Marigold significantly limited growth of leaves of the vegetables. In cultivation with marigold (MA and PA) both yield of carrot leaves and yield of parsley leaves were smaller.

DISCUSSION

In study yields of parsley roots were a lot smaller than those of carrot, which confirms the fact of greater sensitivity of parsley on conditions of germination [Błażewicz-Woźniak 2004]. In the research both vegetables produced best yield in intercropping with onion (MC and PC). Both total and commercial yield of carrot and parsley, and additionally yield of leaves, were highest when cultivated alongside onion. Onion belongs to a different botanic family. It is not competitive to root vegetables due to its morphological and nutritive characteristics. It does not shade them; shallow root system does not compete for water and nutrients, and does not deform storage roots of carrot and parsley.

Many authors also confirm positive allelopathic protective influence of onion and carrot. An obvious benefit of proximity of these species is the restrictive effect on presence of pest, especially *Psila rosae* and *Thrips tabaci* [Uvah and Coaker 1984, Legutowska et al. 2001, Mateeva et al. 2002, Wiech and Kałmuk 2005]. Analysis of carrot and parsley yield structure confirmed beneficial effect of onion on the increase of marketable roots share in yield, although in case of parsley the greatest share of marketable roots was noted in pure sowing. Intercropping of parsley with carrot decreased its commercial yield. Decreased yield of *Petroselinum crispum* (Mill.), in intercropping with *Arracacia xanthorrhiza* (Bancroft) in comparison to homogenous cultivation was noted by Heredia Zárate et. al. [2008]. It is interesting to note that carrot produced slightly higher yield when cultivated with parsley than in homogenous cultivation. Perhaps, despite many similarities between these species, parsley is less competitive towards carrot than carrot is towards itself.

The summary of the total yield obtained from the applied combinations of vegetable cultivation showed interesting results. Taking into consideration the complete result of intercropping, that is a marketable yield of vegetables harvested from area unit, it turned out that cultivation of carrot with onion was most promising. If the purpose of cultivation is to obtain yield of several vegetables, then with slight decrease of carrot yield from the same area, it is possible to gather a high yield of onion at the same time. It is worth recommending especially that in previous research it had proved that intercrop-

ping of onion with root vegetables did not lead to reduce yield [Błażewicz-Woźniak et al. 2005]. An increase of efficiency from area unit was noted in intercropping of carrot with corn [Ogbuehil and Orzolek 1987] and carrot with pepper [Suresha et al. 2007].

In 2005, intercropping of carrot with parsley turned out to be yet another beneficial combination. This could coincide with weather conditions that supported growth of root vegetables. In that year parsley emergence were most numerous and most mass of leaves was created. Analysis of parsley yield in intercropping brought interesting results. Parsley is a vegetable that is rather unreliable in terms of yielding, especially on compact soil with unstable structure [Błażewicz-Woźniak 1998, 2005]. It was shown that in cultivation of parsley in such conditions, intercropping with onion is beneficial, because decreasing commercial yield of parsley by merely 0.37 kg m^{-2} it led to satisfactory yield of onion and to a total yield of both vegetables of approximately 2.38 kg m^{-2}.

Undoubtedly, intercropping of carrot and parsley with marigold proved to be unfavorable combination. Despite differences in requirements and structure of root system, marigold is too competitive for root vegetables. It created heavy aboveground mass suppressing carrot and parsley. The only advantage of intercropping with marigold is a decreased yield of sick and branched roots of carrot and parsley, which can be accounted for by allelopathic effect of marigold in restricting the presence of soil nematodes [Chakraborti 2003, Sturz and Kimpinski 2004]. The active nematicidal component from marigold is thiophene α-terthyenil [Bakker et al. 1979]. It can reduce populations of plant-parasitic nematodes and other disease causing organisms, such as fungi, bacteria, insects, and some viruses [Hethelyi et al. 1986]. In research of Poniedziałek et al. [2010] intercropping of carrot with *Tagetes* and *Calendula* had positive effect on both size and quality of yield, as well as on restricting presence of carrot pests. The effect, however, depended on research year. Different results of carrot yielding obtained by these authors should be accounted for by greater spacing in carrot cultivation (67.5 cm) which decreased competitiveness of marigold.

Bedi and Kaul [1995] showed that extracts of fresh leaf, stem and root tissues of *Tagetes* spp., inhibited seed germination (20–65% in radish and 6.25–37.5% in lettuce) and root growth of radish. In the study, no negative effect of marigold on seed germination of carrot and parsley was noted. The amount of germinating plants was modified more by weather changes than by intercropping. This confirmed high requirements for conditions of cultivation of plants from *Apiaceae* family, especially in the period of their germination and emergence [Finch et al. 1998, Błażewicz-Woźniak 2004, Whalley et al. 2004].

CONCLUSIONS

1. Among all compared combinations of cultivation, the most favorable for carrot and parsley was intercropping with onion. Carrot and parsley cultivated alongside onion produced the highest yield of marketable roots, total yield and yield of leaves.

2. Onion growing in proximity of root vegetables had positive influence on the structure of root yield, especially on carrot by increasing share of commercial roots.

3. Intercropping of carrot and parsley with marigold had unfavorable effect on yielding and growth of these vegetables. This combination led to the lowest yield of marketable

roots, total yield and yield of leaves. In comparison to other combinations of cultivation, share of fine roots in the yield was highest and of marketable yield was the lowest.

4. Intercropping did not affect the number of carrot and parsley emergence, nor yield of fine roots.

5. Total marketable yield of vegetables obtained from intercropping with onion was greater than one from homogenous cultivation. The effect of intercropping of carrot with parsley was modified by year of research.

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WPŁYW UPRAWY WSPÓŁRZĘDNEJ NA PLONOWANIE WARZYW KORZENIOWYCH Z RODZINY *Apiaceae*

Streszczenie. Współrzędna uprawa warzyw przeżywa renesans wraz z upowszechnianiem się upraw ekologicznych. Uprawa obok siebie kilku gatunków roślin likwiduje negatywne cechy uprawy jednorodnej, sprzyja bioróżnorodności i jest zgodna z zasadami rolnictwa zrównoważonego. Marchew i pietruszka korzeniowa to warzywa o dużych wymaganiach w stosunku do warunków wzrostu i uprawa ich wraz z innymi gatunkami jest świadomym wprowadzeniem roślin konkurencyjnych, dlatego też interesujące było sprawdzenie ich reakcji na uprawę współrzędną. Spośród porównywanych kombinacji uprawy najkorzystniejsza dla marchwi i pietruszki okazała się współrzędna uprawa z cebulą. Uprawiane współrzędnie z cebulą wytworzyły największy plon korzeni handlowych, plon ogółem oraz plon liści. Cebula rosnąc w ich sąsiedztwie wpłynęła dodatnio na strukturę plonu korzeni zwłaszcza marchwi, zwiększając udział korzeni handlowych. Niekorzystny wpływ na plonowanie i wzrost marchwi i pietruszki miała uprawa współrzędnie z aksamitką. Uprawa współrzędna nie wpłynęła na liczbę wschodów marchwi i pietruszki oraz na plon korzeni drobnych. Łączny plon handlowy warzyw uzyskany z uprawy współrzędnej z cebulą był większy niż z uprawy jednorodnej. Efekt uprawy współrzędnej marchwi z pietruszką był modyfikowany rokiem badań.

Słowa kluczowe: uprawa jednorodna, marchew, pietruszka, aksamitka, cebula, plon

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