

Influence of preplant and vegetable crop rotation links on carrot yield and damage of pests

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At the Lithuanian Institute of Horticulture in 2003–2007 there were investigated the most suitable plants for green manure and evaluated their influence on ecologically grown carrot yield and damage of pests. Experiments were carried out in the experimental field for ecological vegetable growing, in calcareic epihypogleyic luvisol of sandy loam on light loam. It was established that biomass of the plants grown for green manure left in the ploughing layer uneven amount of organic matter. Pea and oat mixture produced the biggest amount of organic matter (43.2 t ha⁻¹), barley – the least one (24.5 t ha⁻¹). All the sideral plants influenced humus positively. All the preplants increased carrot yield. The biggest carrot yield (correspondingly 40.4 and 41.2 t ha⁻¹) was obtained growing them after barley and pea-oat mixture for green manure. In the first year after harvesting of the plants for green manure, when carrot yield was gathered, there was found only very small amount of root-crops damaged by pests (*Psila rosae* Fabr. and *Pemphigus phenax* Born et Blunck). At the end of rotation, i. e. in third year after plant ploughing for green manure, the percent of carrot root-crops damaged by pests increased. The least amount of damaged root-crops was found in carrot, which preplant in the beginning of rotation was barley for green manure.

Key words: carrot root-crops, crop rotation, green manure, marketable yield, *Pemphigus phenax*, *Psila rosae*.

Introduction. Carrot is widely grown vegetable in Lithuania especially valued because of carotene in its content (Gaučienė, 2001; Gaučienė, Viškelis, 2001). It is rather difficult to grow carrot ecologically, since they are demanding to nutrients, besides, they are attacked by diseases and pests. The most prevalent carrot pests are carrot flies, aphids and bugs.

The suitable selection of preplants and creation of crop rotations is one of the most important means to supply nutrients to ecologically grown plants, to destroy weeds and to protect plants from diseases and pests. Soil preparation and sowing time, the ratio of humidity and nutrients in the soil, weediness, pest prevalence in the crop and the degree of infection by diseases depend on preplant (Danilčenko et al., 2004; Luik, 1997; Lampkin, 1990).

Sideral plants for green manure play important role in the crop rotation of

ecological vegetable growing. In recent years they became especially popular, because only little amount of manure is accumulated in farms. Besides, green manure is much more cheaper and its influence in the first year often is better than this of manure (Алексеев, 1996; Arlauskienė, Maikštėnienė, 2002). For green manure, leguminous plants are sown most often (Abiodun et al., 2008; Šarūnaitė et al., 2008), but as the experience of foreign countries show, cereals are good as well (Andersson, Wivstad, 1992). Various plant mixtures are especially suitable. After the ploughing of the plants for green manure, the soil is enriched by much organic matter, biological soil properties improve, and because of the phytoncides present in crucials phytosanitaric condition of the soil improves also (Žekonienė, 2002; Pretty, 1995). It is recommended to select for carrot in crop rotation early preplants, in order soil structure would be regenerated. Otherwise, there are good conditions for carrot fly development (Lampkin, 1990).

The aim of the study is to select the most suitable plants for green manure and to establish their influence on ecologically grown carrot yield and pest prevalence in the crop.

Object, methods and conditions. Experiments were carried out at the Lithuanian Institute of Horticulture, in the experimental field for ecological vegetable growing in 2003–2007. Soil – calcaric epihypogleyic luvisol of sandy loam on light loam (*IDg 8-k, / Calc(ar)i –Epihypogleyc Luvisols LVg-p-w-cc*) (Buivydaitė et al., 2001). pH_{KCL} of ploughing layer – 7.4, agile phosphorus (P_2O_5) – 211–370 mg kg^{-1} , agile potassium (K_2O) – 151–249 mg kg^{-1} , humus 1.64 – 1.69 %, mineral nitrogen at a depth of 0–60 cm – 92 kg ha^{-1} .

Two field experiments were carried out according to the same schema; one of them was started in 2003, the other – in 2004.

In the first year, for green manure there was grown barley, barley with clover undercrop (of the first year), summer wheat, and peat-oat mixture. Black fallow was regarded as control. In the second year, after each plant for green manure there were grown vegetables of four types – carrot, red beet, onion, and cabbage. Plants were grown according to the s c h e m e:

First yield – Second year – Third year – Fourth year
 Various plants for green manure – Cabbage – C a r r o t – Red beet
 Various plants for green manure – C a r r o t – Red beet – Onion
 Various plants for green manure – Red beet – Onion – Cabbage
 Various plants for green manure – Onion – Cabbage – C a r r o t.

Investigations were carried out in four replications. Area of sidental variants (of all the plots) was 264 m^2 . Area of vegetable record plots – 14 m^2 . Preplant of the plants for green manure – black fallow.

Early in the spring, when the soil is already dry, it is cultivated and harrowed. In the second decade of May for green manure there were sown summer wheat (180 kg ha^{-1}), peat and oat mixture (125 : 125 kg ha^{-1}) and barley (170 kg ha^{-1}). When they germinated, half of barley field was sown with clover undercrop (14 kg ha^{-1}). Seed rate was calculated in 100 % economical value.

Pea and oat mixture was cut during mass blooming, summer wheat and barley – during spikes forming. Grass was chopped fine and ploughed up. Straw was raked

from the plot, in which clove undercrop was sown, and late in the autumn clover was ploughed down. Black fallow was cultivated according to layer method: twice ploughed, three times cultivated. In order to establish plant fresh weight yield, in 10 m² area of every plot plants were cut and weighted. For determination of dry matter and yield and chemical analyses, the sample of 1 kg fresh weight was taken.

Pest damages to carrot root-crops were evaluated during harvesting: the injured carrots were selected, weighted and the percent of damage from the total yield was established. During vegetation, carrot crop was observed according to the standard methods of disease and pest record (Žemės ūkio augalų kenkėjai, ligos ir jų apskaita, 2002). Experimental data was statistically processed by ANOVA program (Tarakanovas, Raudonius, 2003).

Meteorological conditions. The spring of 2003 was dry, but warmer than the multiannual average. Growth conditions for plants designed for green manure were average. Summer time and September were slightly warmer, but the amount of precipitation was close to the multiannual average. In 2004 air was cooler and more humid than the multiannual data show, but the conditions for carrot growing were favourable. In May and June of 2005, there was more precipitation than on the average. July was hot and dry. August was much more humid than usually. Conditions for carrot germination, growth and maturing were average. The summer of 2006 was hot and very dry. Average air temperature was almost 1 °C higher than the multiannual average, and precipitation fell 20.5 mm less than the multiannual average. July and August were especially dry and hot; September was warm in comparison with the multiannual average, but humid (there was 1.5 more precipitation than the multiannual average). In 2007 vegetation period was cool. Air temperature in April–October was 1.2 °C lower than the multiannual average, and precipitation fell 12.8 mm more than the multiannual average.

Results. According to the average data of two years, pea-oat mixture produced the biggest amount (43.2 t ha⁻¹) of fresh weight, and barley – the smallest one (24.5 t ha⁻¹) (Table). Their fresh weight in comparison with this of pea-oat mixture decreased 18.7 t ha⁻¹. The biggest amount of dry matter (7.3 t ha⁻¹) was ploughed down with summer wheat fresh weight. The amount of barley, barley with clover undercrop, and pea-oat mixture dry matter was correspondingly smaller 1.8, 1.4, 0.8 t ha⁻¹. The calculation of the amount of nutrients ploughed down into soil together with fresh weight showed that 104 kg ha⁻¹ of nitrogen got into soil together with pea-oat fresh weight. This is 42 kg ha⁻¹ more than after barley, 17 kg ha⁻¹ more than after barley with clover undercrop, 6 kg ha⁻¹ more than after summer wheat. The biggest amount of phosphorus (21.0 kg ha⁻¹) got into soil when barley with clove undercrop fresh weight was ploughed down, the least one (14 kg ha⁻¹) – when barley fresh weight was ploughed down. The biggest amount of potassium (150 kg ha⁻¹) with fresh manure was introduced by ploughing down pea-oat mixture, the least amount (79 kg ha⁻¹) – by ploughing down barley.

Table. Amount of nutrients in over-ground mass of sideral plants
Lentelė. Maisto medžiagų kiekis sideratinių augalų antžeminėje masėje

Babtai, 2003–2004, average data of both fields
 Babtai, 2003–2004 m., vidutiniai abiejų laukų duomenys

Variants Variantai	Organic manure Organinės trąšos (t ha ⁻¹)		Nutrients Maisto medžiagos (t ha ⁻¹)		
	natural expression natūralioji išraiška	dry matter sausosios medžiagos	N	P ₂ O ₅	K ₂ O
Black fallow (control) Juodasis pūdymas (kontrolė)					
Barley for green manure Miežiai žaliajai trąšai	24.5	4.1	62	14	79
Barley with clover undercrop for green manure Miežiai su dobilų įsėliu žaliajai trąšai	30.2	5.9	87	21	121
Summer wheat for green manure Vasariniai kviečiai žaliajai trąšai	32.5	7.3	98	19	125
Pea-oat mixture for green manure Žirnių-avižų mišinys žaliajai trąšai	43.2	6.5	104	20	150
	LSD ₀₅ / R ₀₅ 3.0		0.5		

In the first year after plant gathering for green manure (in I field – in 2004, in II field – in 2005) all the preplants increased yield. Carrot marketable yields in comparison with the yields obtained growing carrot after black fallow increased on the average 12.5 t ha⁻¹. The biggest carrot yields (correspondingly 40.4 and 41.2 t ha⁻¹) were obtained growing them after barley and pea-oat mixture for green manure (Fig. 1).

Carrot marketable yields in comparison with the yields obtained growing carrot in black fallow field increased 14.2 and 14.9 t ha⁻¹. Summer wheat and pea with clove undercrop for green manure also significantly (correspondingly 11.4 and 9.4 t ha⁻¹) increased root-crop yield.

Barley and barley with clove undercrop were the best preplants for carrot grown after cabbage (in the second year after green manure ploughing up, in I field – in 2005, in II field – in 2006). Carrot marketable yields in comparison with the yields obtained growing carrot after cabbage in black fallow field increased 7.1 and 6.2 t ha⁻¹. Summer wheat for green manure also 2.2 t ha⁻¹ increased marketable root-crop yield. Nevertheless, growing carrot after cabbage, which preplant was pea-oat mixture, there was obtained 0.8 t ha⁻¹ smaller yield in comparison with the yield obtained growing carrot after cabbage in black fallow field.

In the third year after plant gathering for green manure (in I field – in 2006, in II field – in 2007), when carrot was grown after cabbage and onion, the tendency of carrot yield decrease was observed in comparison with the yields obtained in the first and second years of growing.

The most durable preplants were barley and summer wheat. Carrot marketable yield, growing them after cabbage and onion, increased correspondingly 5.8 and 5.4 t ha⁻¹, in comparison with the yield, which produced carrot grown in black fallow field.

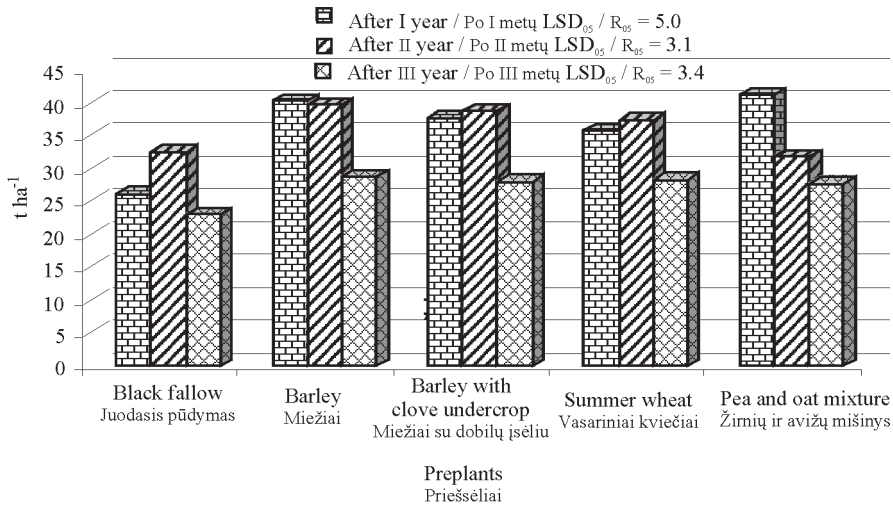


Fig. 1. Influence of preplants and crop rotation links on carrot root-crop marketable yield
1 pav. Priešsėlių ir sėjomainos grandžių įtaka morkų šakniavaisių prekyiam derliui
 Babtai, average data of 2004–2006 and 2005–2007 /
 vidutiniai 2004–2006 ir 2005–2007 m. duomenys

In the first year after plant gathering for green manure, when carrot was harvested, there was found very small amount of root-crops damaged by pests. Only 0.2 % of damaged root-crops were found in carrot grown after black fallow and 0.1 % – after barley for green manure.

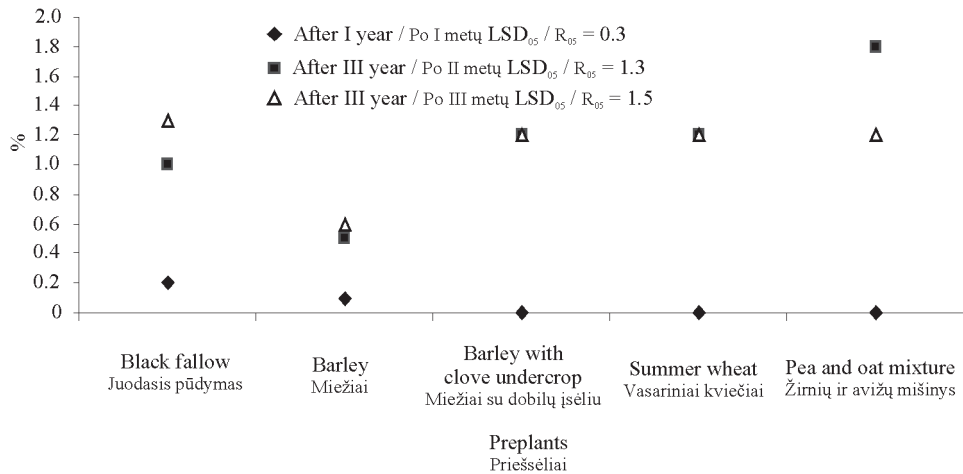


Fig. 2. Influence of preplants on pest (*P. rosae* Fabr. and *P. phenanax* Born et Bunck) prevalence in carrot
2 pav. Priešsėlių įtaka kenkėjų (*P. rosae* Fabr. ir *P. phenanax* Born et Bunck) išplitimui morkose
 Babtai, average data of 2004–2006 and 2005–2007 /
 vidutiniai 2004–2006 ir 2005–2007 m. duomenys

In the second year after plant gathering for green manure, on the average the biggest amount (1.8 %) of damaged root-crops in comparison with control was found in carrot grown after cabbage, which preplant – pea-oat mixture. On the average the least amount (correspondingly 0.5–0.6 %) of damaged root-crops in comparison with control was found in carrot grown after cabbage, which preplant – barley and barley with clover undercrop.

In the third year after plant gathering for green manure, the amount of damaged root-crops in all the plots was similar and fluctuated from 1.2 up to 1.3 %. Nevertheless, in carrot, which preplant in the beginning of crop rotation was barley ploughed up for green manure, there were only 0.6 % of damaged carrot.

In the third year after plant gathering for green manure the percent of damaged carrot root-crops increased and marketable root-crop yield decreased.

Discussion. In Integrated Plant Protection (IPP), cultural measures like preplants and plant rotation play very important role; especially it is important in ecological farming (Glosary et al., 1997). While growing carrot ecologically, green manure is one of the means to increase the amount of nutrients in the soil and to improve vegetable productivity. In crop rotation, when plants are being fertilized with green manure, much nitrogen, phosphorus and potassium is left in the soil (Kozlova, Kaminski, 1998), but different plants assigned for green manure differently enrich the soil with organic matter. The biggest amount of fresh weight produced red cloves (Šlepetienė, Kinderienė, 2007). The same tendency was observed in the investigations carried out at the LIH.

Scientists (Thorup-Kristensen, Boogaar, 1999; Rosa, Jabłońska-Ceglarek, 2008) established that all the plants for green manure increased carrot root-crop and other vegetable yield, but it was difficult to control carrot pests. Organic growers have had to rely on techniques such as covering the crop with a fine-mesh netting and manipulating the time of sowing and harvest (Ellis et al., 1987; Jönsson, 1992). The former method is costly, and conditions under the netting can be favourable to the development of fungal pathogens and weeds (Eichin et al., 1987; Peacock, 1991). A delay in sowing or premature harvesting both may result in yield losses (Ellis et al., 1987). In our study effect of preplants used for green manure detectible also after three years. After one-year effect of preplants for reducing damage of pests was highest, maybe field was clean from pupa of carrot fly. The preplant barley reduced the harm of carrot pests during all the years and standard yield losses were the smallest. According to Rämert (1996 b), growing vegetables ecologically predators play very important role. We suggest that in treatment with barley predators inhibited pests.

Conclusions. 1. Pea and oat mixture produced the biggest amount of fresh weight (43.2 t ha⁻¹), barley – the least one (24.5 t ha⁻¹).

2. All the sideral plants influenced the positive changes in humus.

3. All the preplants increased carrot yield. The biggest carrot yields (correspondingly 40.4 and 41.2 t ha⁻¹) were obtained growing them after barley and pea-oat mixture for green manure.

4. In the first year after plant gathering for green manure, when carrot was harvested, there was found very small amount of root-crops damaged by pests (*P. rosae* and *P. phenax*). At the end of crop rotation, i. e. in the third year, after plant gathering for green manure the percent of pest damaged carrot root-crops increased. The least amount of damaged root-crops was found in carrot, which preplant in the beginning of crop rotation was barley for green manure.

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Priešėlių ir daržovių sėjomainos grandžių įtaka morkų derliui ir kenkėjų daromiems pažeidimams

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Santrauka

Lietuvos sodininkystės ir daržininkystės institute 2003–2007 metais ekologiškoms daržovėms auginti paruoštame bandymų lauke tirti žaliajai trąšai tinkamiausi augalai ir įvertinta jų įtaka ekologiškai auginamų morkų derliui bei kenkėjų daromiems pažeidimams. Nustatyta, kad žaliajai trąšai auginamų augalų biomasė armenyje paliko nevienodą organinės medžiagos kiekį. Daugiausia žaliosios masės (43,2 t ha⁻¹) užaugino žirnių ir avižų mišinys. Vasariniai kviečiai – 32,5 t ha⁻¹, miežiai su dobilų įsėliu – 30,2 t ha⁻¹. Mažiausiai žaliosios masės užaugino miežiai – 24,5 t ha⁻¹. Humuso teigiamais pokyčiams įtakos turėjo visi sideraliniai augalai. Visi priešėliai

didino morkų derlių. Didžiausias morkų derlius (atitinkamai po 40,4 ir 41,2 t ha⁻¹) buvo auginant jas po miežių ir žirnių-avižų mišinio žaliajai trąšai. Pirmais po augalų nuėmimo žaliajai trąšai metais, nuėmus morkų derlių, kenkėjų (*Psila rosae* Fabr. ir *Pemphigus phenax* Born et Blunck) pažeistų šakniavaisių buvo rasta labai nedaug. Rotacijos pabaigoje, t. y. trečiais po augalų užarimo žaliajai trąšai metais, padidėjo kenkėjų pažeistų morkų šakniavaisių procentas. Mažiausiai pažeistų šakniavaisių rasta morkose, kurių priešsėlis rotacijos pradžioje buvo miežiai žaliajai trąšai.

Reikšminiai žodžiai: morkų šakniavaisiai, *Pemphigus phenax*, prekinis derlius, *Psila rosae*, sėjomaina, žaliaji trąša.

