CHIEF INSPECTORATE OF PLANT HEALTH AND SEED INSPECTION

DRAFT

METHODOLOGY
OF INTEGRATED PRODUCTION OF ROOT AND LEAF PARSLEY

Approved
pursuant to Article 57(2)(2) of the Plant Protection Products Act of 8 March 2013 (Journal of Laws of 2024, item 630)

by
the Main Inspector of Plant Health and Seed Inspection

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I. INTRODUCTION

Integrated Plant Production (IP) is a modern food quality system that makes sustainable use of technical and biological progress in cultivation, plant protection and fertilisation, paying particular attention to the protection of the environment and human health. The basic element of the system is the application of the principles of integrated pest management, which apply to all professional users of plant protection products from 1 January 2014. These principles in particular prioritise the use of non-chemical methods, which should be supplemented by pesticide use when predicted economic losses caused by agrophages are greater than the cost of treatments.

Among others, application of IP is a guarantee of production of high-quality food, not exceeding permissible residues of harmful substances, less expenditure on production (fertilising based on the actual demand of plants for nutrients), and the rational use of plant protection products. Moreover, it helps reduce environmental pollution with chemical plant protection products, enhances biodiversity of agrocenoses and raises awareness among consumers and fruit and vegetable producers. Integrated Plant Production in 2007 was recognised by the Ministry of Agricultural and Rural Development as a national food quality system with particular emphasis on Integrated Plant Protection (IO) against harmful organisms.

The certification system in Integrated Plant Production is managed by certification entities authorised and supervised by provincial plant health and seed inspection services.

The legal provisions regarding Integrated Plant Production are regulated by the Plant Protection Products Act of 8 March 2013 (Journal of Laws of 2024, item 630), Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on documenting activities related to Integrated Plant Production (Journal of Laws of 2023, item 2501), Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on qualifications of persons conducting control activities in relation to compliance with the requirements of Integrated Plant Production and a model certificate confirming the implementation of Integrated Plant Production (Journal of Laws of 2024, item 180), and Regulation of the Minister for Agriculture and Rural Development of 8 May 2013 on training in the area of plant protection products (Journal of Laws of 2022, item 824).

The methodology of integrated production of root and leaf parsley covers all issues related to cultivation, fertilisation, site selection, crop rotation, soil preparation, sowing, irrigation, agrotechnical treatments, variety selection, as well as protection against pests, harvesting, and storage. It also discusses the hygiene and sanitary rules that need to be complied with during the harvest and preparation of crops produced in the IP system for sale, and the general rules governing the issue of IP certificates.

This methodology was developed based on the results of proprietary research carried out at the Institute of Institute of Horticulture — National Research Institute and the latest data from the literature, in compliance with the Integrated Plant Protection requirements

and the guidelines of the International Organisation for Biological and Integrated Control (IOBC), and of the International Society for Horticultural Science.

II. AGROTECHNICS IN INTEGRATED PRODUCTION OF ROOT AND FLAT-LEAF PARSLEY

Dr Natalia Skubij

2.1. Origin and description of the species

Parsley (*Petroselinum crispum* (Mill.) Nyman ex A. W. Hill) is a vegetable belonging to the family *Apiaceae* Lindl., of which two botanical varieties are cultivated: **root parsley** (*P. crispum* var. *tuberosum* (Bernh. Mart. Crov.) and **leaf parsley** (*P. crispum* var. *foliosum*). In addition, root parsley is divided into two forms:

- *langum* – primary form with a long, sharply pointed, late-developing root;
- *bereve* Alef. – with a storage root, shorter than in the previous form, developing rapidly. This group includes varieties listed in the National Varieties Register.

Root and leaf parsley originate in southern Europe from the Mediterranean coast: from Spain to Greece; they are also found in Macedonia, Crimea, as well as in Algiers. Currently, they are found in the wild throughout Europe, America, Africa, Australia, and Japan, where they grow most often at springs and on limestone rocks.

Root parsley is a biennial plant. In the first year of cultivation, it forms a lush rosette of leaves composed of 15-30 leaves, with a triply pinnate, smooth, shiny leaf blade and long petioles. During this period, parsley also develops a storage root, which is formed from the part of the hypocotyl and epicotyl stem and from the base of the taproot. The first two parts form the upper part of the bulge, 1-2 cm long. This is the so-called head, from which the inflorescence shoot grows in the second year of vegetation. On the other hand, the remaining part of the storage root grows lateral roots in four longitudinal rows. Some of them thicken, which leads to bifurcation of storage roots. The storage root is more or less elongated, cylindrical or tapering downwards. The cross section shows an axial cylinder representing ½ to ¾ of the root and a cortical layer in the form of a narrow outer strip. The storage roots of individual varieties differ, among others, in the colour and surface of the skin, the colour of the bark, and the central cylinder. In the second year of vegetation, leaves and a leafy, branched inflorescence up to 1 m in height grow from the head of the storage root. Parsley flowers are bisexual, greenish-yellow in colour, arranged in compound umbels, situated at the tops of the branches of the inflorescence shoot. The fruit is a schizocarp, splitting into two achenes upon reaching maturity. In the shell of the seeds, there are distinct ribs and tubules filled with essential oils, imparting a fragrance.

In the first year of cultivation, leaf parsley forms an inedible root and a rosette of leaves. The storage root in the upper part is cylindrical and smooth, while the lower part is strongly branching with a large number of lateral roots. The rosette of a well-grown plant consists of 20–50 leaves. Leaf rosettes can be erect, semi-erect, and scattered. The leaves are shiny, dark

green, trifoliate. Due to the appearance of the leaf lamina, two forms of leaf parsley are distinguished:

- flat-leaved (*P. crispum* var. *neapolitanum*) - with smooth, wide leaves, on short stalks,
- curly (*P. crispum* var. *crispum*) – with bi- or tri-pinnate leaves, large, strongly curly, set on thick, long petioles.

Among them are cultivars developed through enrichment breeding. The shape of the leaves of leaf parsley is not a completely established feature; when propagated from seed, quite significant differences in the shape of the leaves can occur. In the second year of cultivation, leaf parsley produces yellow-green umbels and seeds similar to root parsley.

The edible part of leaf parsley is the leaves, whereas for root parsley, it is both the roots and the leaves.

100 g of fresh root weight (with an energy value of 74.3 kcal) contains 2.85 g of protein, 15.71 g of carbohydrates, trace amounts of fats, 81.4 mg of calcium, 37.1 mg of phosphorus, 5 mg of iron, and 25.7 mg of magnesium. In the root of parsley, there are also vitamins: 27.1 mg of vitamin C, 3.4 mg of vitamin PP, 0.14 mg of vitamin B_2, 0.17 mg of vitamin B_1, vitamin A – 105 IU. However, the leaves of root parsley have an even greater biological value. In 100 g of green leaves with an energy value of 174 kcal, there are approximately 11.2 g of protein, 2.8 g of fats, 25.7 g of total carbohydrates, 193 mg of calcium, 200 mg of phosphorus, 900 mg of potassium, 18 mg of iron, 54 mg of magnesium, and vitamin A – 18 000 IU, C- 200 mg, B_2 - 0.75 mg, B_1 - 0.35 mg, PP- 5.2 mg. Carotenoids and essential oils, the most important of which is apiol, as well as flavonoids, are also present in the leaves and roots of root parsley.

Parsley leaf blades are an equally rich source of vitamin C (amount 6 times greater than root parsley), provitamin A, B vitamins (B_1, B_2, B_6), as well as iron, potassium, magnesium, calcium, copper, phosphorus and carotene.

2.2. Climatic and soil conditions, site in rotation

Root parsley and leaf parsley are temperate climate plants grown on most soils found in Poland. However, the best soils for their cultivation are medium-textured, with good structure, fertile, humus-rich, with high water retention capacity and a pH close to neutral (6.5-7.5). However, heavy soils that easily crust, are waterlogged, or are too light with a shallow arable layer are not suitable.

Parsley is a vegetable that is sensitive to both a scarcity and an excess of water in the soil. Water requirements for root and leaf parsley are high, especially during seed emergence. With a lack of moisture or periodic drought during this period, the germination time of seeds is significantly increased, resulting in uneven plant emergence. On the other hand, the water deficit in the later stages of vegetation, at the stage of growth and thickening of the storage root in root parsley, is one of the reasons for the shortening and forking of the root. Excessive soil moisture in the cultivation of these plants is also unfavourable, as it may cause more intensive development of diseases and a decrease in yield. Intense precipitation after sowing seeds is equally harmful, as it leads to the formation of a crust that hinders or even prevents the emergence of young seedlings.

Parsley is a plant that is highly sensitive to the lack of air in the soil environment; therefore, short-term flooding of the soil can lead to the death of plants. If plants survive periodic flooding, they are then more susceptible to attack by pathogens. Therefore, parsley plantations should not be established in places where water stagnation persists for a long time after rainfall.

The heat requirements of root parsley and leaf parsley are lower than in other root vegetables. Seeds of these plants begin to germinate at a temperature of 2 to 3°C, and young seedlings tolerate frosts down to -9°C. Well-developed roots of late varieties show less sensitivity to low temperatures and can overwinter in the field under a cover of snow or leaves. For proper growth and development, root parsley and leaf parsley require an optimal temperature in the range of 16-18°C. Temperature drops during the emergence and juvenile growth period are unfavourable, as they can contribute to the phenomenon of bolting.

Light requirements for root and leaf parsley are high. The best yields are obtained when parsley is cultivated in sunny and warm locations. Root parsley cultivation is also possible in semi-shaded areas, but the plants then exhibit less root growth. Parsley is a plant that does not react to the length of the day.

Leaf parsley and root parsley are vegetables sensitive to preceding crops. Therefore, they should not be grown after themselves and other plants of the Apiaceae family, as well as after other root vegetables, for at least 4 years. Shorter breaks in cultivation are not advisable, as they are conducive to the occurrence of certain pests, such as the pin nematode (*Paratylenchus bukowinensis* (Micoletzky)) or the northern root-knot nematode (*Meloidogyne hapla* (Chitwood)). Sites for root and leaf parsley plantations should not be located near larger clusters of trees (especially poplars), shrubs, and other thickets. In the rotation, parsley is best considered after plants with low nutrient requirements and after species with a shallow root system. The list of crops that are beneficial and unsuitable for various reasons as forecrops for root and leaf parsley is set out in Table 1.

Table 1. List of plants recommended and not recommended as precursor for parsley

Recommended	Not recommended
• leguminous plants (i.e. beans, seradela, lupin, soybean, pea, field bean, clover, alfalfa) • cereals (wheat, barley), phacelia • vegetables from the cucurbit family (including cucumber, pumpkin, courgette) • brassica vegetables (including cabbage, cauliflower, broccoli, rape, turnip rape, mustard, radish)	• other root vegetables (e.g. carrots, parsley, parsnips, celery, beetroot – development of the same pathogens and deterioration of soil structure) • Solanaceae vegetables (including: tomato, pepper - reduction of soil nutrient richness, potato - deterioration of soil structure) • other plants of the Apiaceae family (source of occurrence of the same diseases and pests)

2.3. Fertilisation

On good sites with fertile soils, root parsley and leaf parsley are usually grown in the second year, and even in the third year after manure, using mineral fertilisation according to the plants' needs. When establishing a parsley plantation on light soils, poor in humus, it is cultivated in the first year after manure. For natural fertilisers, the nitrogen dose of 170 kg N/ha/year (Directive 91/675/EEC) shall not be exceeded. According to the Code of Good Agricultural Practice, the dose of manure with an average nitrogen content of about 0.5% N should not exceed 35 t/ha. It is also important that solid natural fertilisers are applied within the deadlines specified in the Action Programme to reduce water pollution by nitrates from agricultural sources and to prevent further pollution (Journal of Laws of 2023, item 244). The optimal time for fertilising with natural fertilisers is early spring; however, for parsley (especially early varieties), it is more advantageous to apply manure in autumn, and it should be ploughed immediately after application.

Manure fertilisation can be replaced by using other organic fertilisers, either own (compost) or purchased. The recommended dose of these fertilisers depends on the nitrogen content and must not exceed 170 kg N/ha. Growing catch crops for ploughing is a good solution. As catch crops, the so-called green fertilisers are recommended. These are most often mixtures of leguminous plants, enriching the soil with nitrogen and organic matter, or species with phytosanitary properties, e.g. phacelia. These plants as green fertiliser must be incorporated during the autumn of the year preceding the crop.

Leaf parsley and root parsley are classified as vegetables with medium nutritional requirements. **Before starting the cultivation of this species, it is necessary to perform a soil richness analysis and determine fertiliser needs (confirmed by the results of soil analysis) and apply optimal fertilisation.** An objective assessment of soil abundance can only be carried out after a chemical analysis of the soil has been conducted. Soil analysis should be carried out at District Chemical and Agricultural Stations or other accredited laboratories. When determining the dose of fertilisers, the soil type (heavy, light soils) and

the exchange sorption of nutrients in the soil should also be taken into account. The optimal soil mineral content for root parsley should be (mg/dm^3): 60-80 N, 40-60 P, 150-250 K, 60-80 Mg, 1000-2000 Ca, and for leaf parsley (mg/dm^3): 80-100 N, 60 P, 150-200 K, 65-10 Mg, 1500-2000 Ca.

After analysing the soil and comparing it with the presented optimal contents, you can decide on fertilisation. The planned fertilisation should take into account the amount of components that will be released as a result of the mineralisation of organic matter brought into the soil from ploughed green fertilisers, manure or compost. For this purpose, the so-called fertiliser equivalents for the applied organic fertiliser given in the Code of Good Agricultural Practice should be used.

Phosphorous and potassium fertilisers in the cultivation of root and leaf parsley are best applied in the autumn in full dosage, to avoid increasing soil salinity during seed germination.

Nitrogen fertilisation in the cultivation of root parsley is applied in spring—once in the entire dose, 7-10 days before sowing parsley in early varieties. A nitrogen dose of up to 80 kg/ha in the form of ammonium nitrate or calcium ammonium nitrate is recommended. In late varieties, nitrogen fertilisation is applied in two or three doses, ranging from 100 to 150 kg N/ha. The first dose before sowing constitutes about ½ of the recommended nitrogen fertilisation. The remaining nitrogen is recommended to be applied in 1-2 stages, during the phase of intensive leaf growth, no later than mid-July. The second top dressing is safest to apply in the form of urea. In years with heavy rainfall and when it is possible to irrigate plantations, the amount of nitrogen can be increased by 30-50% by introducing this additional part as a top dressing, but the application must not exceed the deadline of mid-July.

In the cultivation of leaf parsley, nitrogen fertilisation should be applied in two stages: $^1/_3$ or ½ dose before sowing, the remainder in June or July.

Soil fertilisation for root and leaf parsley cultivation is to be conducted on the basis of the results of soil analysis, in accordance with the recommended levels of N, P, K, Mg, Ca.

In the cultivation of parsley, the soil reaction plays an important role. The optimum pH of mineral soils is 6.5 to 7.5. If the soil pH, determined on the basis of soil samples, is below the specified range, liming should be applied. The dose of lime needed to deacidify the soil is best determined on the basis of the measured soil acidity. The liming treatment should be carried out in autumn or, preferably, in summer, after plants that leave the field early, in the year preceding cultivation. The effectiveness of liming depends on the good mixing of fertiliser with soil. It is recommended to use calcium fertilisers in carbonate form. On the other hand, dolomite lime or magnesium lime should be used on soils poor in magnesium. It should be remembered that liming cannot be carried out simultaneously with manure fertilisation, because it leads to rapid mineralization of manure and nitrogen losses from the

soil. **A chemical analysis to determine the soil pH and Ca content must be carried out in the year preceding the crop (in summer or autumn after the plants have been harvested). After receiving the results of the analysis, if necessary, a liming procedure should be performed. Cultivation is also permitted if the determination of the soil pH is carried out in the year the cultivation begins, provided that the soil pH is within the optimum range for the crop.**

2.4. Soil cultivation

Root and leaf parsley require very careful soil preparation. Farming should be carried out in such a way that air-water relations in the soil and biological processes are not disturbed. Over working of the soil is not recommended, because it may lead to pulverisation, structural deterioration, excessive drying and, subsequently, accelerated humus mineralisation. The surface of the soil should be level and free from lumps, stones, plant or manure residues, which make it difficult to sow the seeds precisely to the appropriate depth. Properly prepared soil for parsley cultivation should have a loosened top layer to a depth of about 5 cm and a relatively compacted deeper layer.

It should be remembered that deep loosening of the soil in the cultivation of these plants allows for its appropriate fragmentation, thereby enabling the production of long and shapely roots in root parsley. It is therefore best to perform these cultivation activities in the autumn, using pre-winter ploughing, ploughing with a subsoiler, or subsoiling. Subsoiling is especially recommended on heavier soils. In the case of excessive loosening of the soil for the cultivation of parsley, a Cambella roller or string roller can be used, which, by appropriately compacting the subsurface layer, reactivates the capillary rise of water from deeper layers.

Root parsley, due to its long growing season, is not cultivated as a catch crop (with the exception of crops for early harvest or pre-winter sowing); it is generally the main crop of the field. It is therefore important to start preparing the soil for the cultivation of this vegetable immediately after the harvest of the preceding crop and, depending on its type and date of harvest, plan to perform appropriate cultivation treatments. If parsley is grown after cereals, it is best to perform shallow tilling or discing and harrowing immediately after harvest. It is then good to sow a cover crop for green manure, e.g. mustard or phacelia, which should be incorporated at least 4 weeks before planting.

The set of spring tillage operations is performed in order to loosen the soil, reduce water losses, destroy weeds, and mix mineral fertilisers. Depending on the site, it should include: harrowing - cultivating - rolling - light harrow - sowing - seed harrow. For crops established on heavier soils, if necessary, deep spring ploughing or subsoiling should be carried out in addition. However, immediately after such ploughing (preferably on the same day), in order to prevent the soil from drying out, a cultivator with a heavy string roller should be used, or ridges should be formed and sown.

Regardless of the type of soil, the field for growing root and leaf parsley should be carefully prepared and properly levelled. Only in such a field can the same depth of sowing be obtained, and as a result - uniform emergence.

2.5. Selection of varieties

Varieties of root parsley are characterised by the distinguishing features of the storage root, the growing season, and the intended use. The shape of the root can be short conical, elongated conical, or cylindrical. The storage roots of parsley varieties vary in length; there is the short root – up to 15 cm, the medium-length root from 16 to 25 cm, and the long root over 26 cm. Varieties with medium-length roots are most often chosen due to the ease of harvest and the potential for processing. However, due to the length of the growing season (number of days from sowing to harvest), root parsley varieties are divided into:

- *early* (reaching maturity after 80-100 days),
- *medium-early* (after 110-120 days),
- *medium-late* (after approximately 130–150 days),
- *late* (after 160–200 days).

In general, the longer the growing season, the higher the yield of the varieties, i.e. the higher the yield of the storage roots.

When choosing a variety of root parsley for cultivation, it is worth considering its purpose, as well as features such as ease of cultivation, resistance to diseases, and frost tolerance. Early varieties are characterised by relatively low frost resistance. Late ones, on the other hand, can be successfully left in the field for wintering, as long as the forecasts do not predict harsh winters.

Varieties of leaf parsley cultivated differ in the degree of leaf blade corrugation and the size of individual leaflets in the compound leaf. These are both varieties with strongly shortened leaves, as well as those having long and thick petioles and very strongly curly leaf blades.

The list of varieties of root parsley and leaf parsley, along with the necessary information on cultivation in the IP system, is published on the website of the Central Research Centre for Cultivated Plant Varieties (COBORU) under the tab ‘Selection of varieties for integrated plant production’ (https://www.coboru.gov.pl/pdo/ipr).

2.6. Methods of cultivation

Root parsley plantations can be established by two methods:

- **flat**

In flat cultivation, the tillage unit or cultivator loosens, grinds, and mixes the soil to a depth of about 15 cm. For the necessary compaction of the soil and restoration of capillarity action, a smooth or string roller is used. Light harrow is then used to loosen the topsoil by 2–3 cm and parsley is sown immediately.

- **on ridges**

When growing on ridges, the soil is loosened using a rotary tiller that is part of a specialised ridge-forming unit. This equipment can also be used in a separate treatment or in plantations established on more compact soil, combined with deep ploughing, and then, in the shortest possible time, ridges formed. In ridges compacted with a special unit, there is better capillary action and easier sowing of seeds to the desired depth. However, in ridges formed with the help of a regular ridger, e.g. for potatoes, the soil can be additionally compacted with a medium roller. However, it is important to sow the seeds on the same day that the ridges are formed. Delayed sowing worsens the conditions for germination of seeds, which delays or prevents the emergence of parsley.

The first method of cultivating root parsley is more effective on permeable soils. On heavy, clay soils, cultivation on ridges is recommended. However, it should be remembered that the soil in the ridges dries faster than in flat areas, and in case of drought, the cultivation of parsley should be watered.

The cultivation of leaf parsley is carried out primarily on a flat surface, using the same cultivation treatments for this method of cultivation as for root parsley.

2.7. Sowing

An important issue in the cultivation of root and leaf parsley is good seed material, characterised by high quality. It is advisable to sow fresh seeds each year, characterised by a high germination capacity, as only such seeds will ensure uniform emergence and consistent plant density. Before sowing, it is worth treating seeds against diseases and pests. It is not recommended to keep parsley seeds until the next year, due to a significant decrease in their germination capacity.

In integrated leaf and root parsley production, it is recommended to sow vegetable seed of at least the standard category, and to store labels and proofs of purchase of the seed.

Dates, standards and methods of sowing

Root parsley is grown by sowing seeds directly into the ground in a permanent location. It is not customary to grow this plant from seedlings, as it is sensitive to transplanting. Parsley is grown on a commercial scale from sowing seeds directly into the ground. On small areas, it can be grown from seedlings, as it tolerates transplanting well, and any deformation of the root system has no practical significance.

Sowing of root parsley

Root parsley is a vegetable characterised by a long germination time of seeds (3-4 weeks) and a long growing period (180-200 days). Therefore, it should be sown early—as soon as it is possible to start cultivating the land (preferably as soon as the top layer of the soil dries). Parsley growing can begin at the turn of March and April. The exact date of sowing will also depend to a large extent on the intended use of the crop.

In the cultivation of root parsley for early (bunch) harvesting, sowing can take place in early spring (late March-April) or late autumn of the previous year (October, November). Sowing of parsley intended for autumn and winter use will take place in the last ten days of April, while for parsley roots intended for storage, it will occur from the end of April to the beginning or even until mid-May.

When planning the date of sowing parsley grown for the autumn harvest, in addition to the purpose of the crop, attention should also be paid to factors such as water availability and soil temperature.

In the seeds of parsley sown in excessively cold soil, the germination period is prolonged and uneven emergences are observed. Weak and uneven emergence can also occur with insufficient water in the soil. Therefore, when cultivating for the autumn harvest, if irrigation of the plantation is not possible, it is best to sow the seeds slightly earlier, for example, in the last ten days of April. Plants sown in April will still benefit from water reserves accumulated in winter. On the other hand, sowing in May carries the risk of weaker germination due to the lack of rainfall and frequent periodic droughts. However, if it is possible to irrigate the plantation, then the sowing date in May is more favourable, because at higher temperatures the plants emerge faster, and the roots from sowing in the second half of May are better preserved.

Root parsley is most often grown from flat sowing, rarely on ridges. The depth of sowing in the cultivation of parsley should be adjusted to the type of soil, the sowing date, and the length of the growing season. If too deep sowing is carried out, it can lead to a delay or limitation of the emergence. Sowing depth for heavier soils is 1-2 cm, for lighter soils - 3 cm, and for peat soils - 4 cm. In the cultivation of parsley, the spacing of the rows and the density of plants in the row depend on the method of care and the purpose of cultivation.

In the cultivation of flat parsley, row or strip-row seeding is most commonly used. The recommended row spacing is 30–45 cm for the autumn harvest or 10–20 (30) cm for the bunch harvest. Three rows every 40 cm or four rows every 28 cm in a belt width of 135 cm (or another width of the tractor) shall be carried out in strip sowing.

Sowing parsley on ridges is recommended on moist and compact soils, due to better ridge formation and more durable deposition. On ridges spaced every 67.5 cm or 75 cm, it is advisable to sow in double rows, 6–8 cm apart, with a distance of about 2.5 cm between seeds in the rows. In general, 80 seeds per 1 linear meter of double row are sown. Sowing can be carried out with a single-row belt sowing machine or a ridge-forming unit with simultaneous sowing.

In the cultivation of parsley, it is possible to perform spot sowing, which reduces the number of seeds used and eliminates the need for thinning. It is important that the coulters of the seed drill are equipped with press wheels that allow the ridges to achieve adequate firmness. Seeding with precision drills ensures that 30–50 seeds are sown per linear metre of the row (however, for seeds with a high germination capacity). If no precision seeder is used and a high density of emergence is observed, thinning of young seedlings should be performed, leaving the plants in a row every 4–6 cm.

Accurate sowing of the recommended amount of parsley seeds requires the use of precision seed drills—pneumatic or mechanical. When using less accurate, wheelbarrow brush drills, to increase the accuracy of sowing, it is recommended to mix parsley seeds with ballast. Dead seeds, i.e. killed by high temperature, are considered ballast. Such ballast of known weight, 2 or 3 times that of live seeds, shall be thoroughly mixed together. The standard for sowing the resulting mixture requires a precise calculation, allowing the required amount of live seeds to be sown.

The standard seed sowing rate per hectare depends to a large extent on the spacing of the rows and the size and quality of the seeds. If seeds with a high germination capacity are available, the sowing rate is 1.5–2 kg of seeds/ha. With seeds with slightly lower germination capacity, the sowing rate should be increased up to 3–4 kg/ha. An important issue regarding the sowing standard is the purpose of cultivation; for crops intended for the autumn harvest, it is 1.5–2 kg or 1–1.5 kg of seeds per hectare (for seeds with 80% and 90% germination capacity, respectively). When growing for the bunch harvest (earliest harvest), parsley is sown more densely, usually at 2–4 kg of seeds per hectare. At a later date, the quantity of seeds increases to 6 kg, and with pre-winter sowing to 7 kg per 1 ha. With late sowing, one should anticipate having to reseed, because not all seeds may germinate.

Due to the long emergence period, it is sometimes practised to sow parsley with an indicator plant (comprising 3 to 5 % of seeds of fast-germinating vegetables, such as radishes, kohlrabi, or lettuce). Its faster emergence marks the future rows of plants, which makes it possible to start inter-row cultivation earlier. For 1 kg of parsley seeds, one can add: 70 g of radish, 50 g of kohlrabi, or 30 g of lettuce.

The emergence of root parsley seeds can be accelerated by germination or stratification. Seeds are sprouted by soaking them in warm water (20–30°C) for 24 hours. The moist seeds are then kept on the dishes at the same temperature for 1–2 days. Be sure to sow the seeds in moist soil, otherwise there may be problems with germination.

Acceleration of seed emergence and faster growth of parsley plants can also be achieved by covering them with perforated film or crop cover. Seedlings are covered for 2-4 weeks. Performing this treatment simultaneously prevents soil crusting and allows for better soil moisture retention.

Sowing leaf parsley

Parsley seeds are sown in late March or in April in rows spaced 25-40 cm apart, with plants within the rows spaced 10-20 cm apart. Sowing is carried out to a depth of 1-1.5 cm. A larger spacing of plants promotes improved leaf quality and shorter leaf petioles, and also facilitates mechanical weeding. However, excessive spacing must not be used, as this may cause the rosettes to decompose, making harvesting much more difficult, especially mechanically. When planning the cultivation of leaf parsley for wintering in the ground, sowing should be carried out in July. In general, 6 kg of seeds are used to sow 1 ha. The emergence of young seedlings occurs after 2-4 weeks, depending on the temperature. With overly dense seedlings, thinning is applied, leaving approximately 10 cm distance between plants in a row. The first harvest is usually carried out 4 months after the date of sowing, with subsequent harvests every four weeks. Single leaves can be harvested successively, but in

large-scale production 3-5 harvests are made (mowing at a height of 5 cm above the ground), generally from the end of June to late autumn.

Celery parsley can also be forced in a greenhouse. For this purpose, in order to obtain roots for forcing, the harvest of leaves should be completed 2-3 weeks before the planned date of digging up the roots. Roots with a diameter at the neck of at least 0.5 cm and a length of 6-8 cm are selected for forcing. Forcing should be conducted in conditions of full light, at a temperature of 10-15°C. The excavated roots are planted at a spacing of 15-20x10 cm. The type of substrate in which the roots are placed is not significant; what matters is its humidity. The first harvest is carried out after 12-15 weeks, usually at the end of December or at the beginning of January, with subsequent harvests every 2-3 weeks, until the end of March.

2.8. Irrigation

Irrigation of plantations is an important issue in the cultivation of root and leaf parsley. The greatest sensitivity to water scarcity in the production of these plants is visible in the initial stages of growth - in the period from sowing to emergence, as well as in root parsley during intensive root growth, i.e. approximately 2 months prior to harvesting. Rapid water loss usually also occurs with delayed sowing and when growing on ridges (as opposed to flat cultivation).

In order to prevent periodic changes in soil moisture, the parsley plantation should be irrigated using a sprinkler, for example. Water shortages on root parsley plantations grown on ridges can also be addressed by the use of drip irrigation.

Sprinkling introduced at the sowing stage should be carried out in small (5-8 mm) fine-droplet doses of water. In the later stages of the development of parsley plants, the periodic loss of water in the soil should be supplemented by irrigating the plantation several times with single irrigation doses (i.e. the amount of water applied per unit area during one irrigation). The amount of a single dose of irrigation depends on: the intended depth of soil wetting, the water capacity of the soil, and its current moisture content. Irrigation of root and leaf parsley crops during prolonged drought should be carried out in such a way as to ensure that the soil is sufficiently moist to a depth of 30-50 cm. Increasing the moisture only in the surface layer can cause intensive forking of roots in the cultivation of root parsley. Irrigation dose with allowable water deficit – 65-75 % FWC (field water capacity) and soil moisture depth: for light soils it is 20-35 mm, for medium soils it is 25-40 mm, and for heavy soils it is 30-45 mm.

During the year, parsley should receive at least 500 mm of precipitation (rainwater and/or irrigation). In the summer, a single dose should be 200-250 mm (2-2.5 thousand m^3 water/ha).

2.9. Physiological disorders

In the cultivation of root parsley and leaf parsley, irregularities in the growth and development of plants may result from physiological disorders associated with the influence

of environmental factors, including inadequate air and water conditions of the soil, periodic drought, or improper agrotechnics. They can also be associated with a shortage, excess, or poor balance of nutrients in the plant, which should be identified through careful observation of the growing conditions and the plants themselves.

The level of macro- and micronutrients significantly affects the life processes of plants, thereby allowing the nutritional status of the plantation to be assessed through chemical analysis of plant material and soil. However, the basis is the ability to recognize external symptoms indicating improper nutrition of plants or changes resulting from agrotechnical reasons in cultivation.

Symptoms of nutrient deficiency or excess on plants may be caused, among others, by:

- hindered transport within the plant under conditions of excessive humidity (>90%),
- water management disorder (too low or too high transpiration),
- incorrect balance of antagonistic nutrients,
- excessive fertilisation,
- deficiency or low nutrient content in soil and/or difficult uptake due to poorly developed or damaged root system (mechanical damage, flooding, salinity, pH too low (<5.5) or too high (>8.5), too high (>24°C) substrate temperature).

Physiological disorders in the cultivation of root and leaf parsley plants can most often be observed in the initial period of development. Then they are associated with the lack of or poor emergence, which is caused by sowing seeds in too dry soil or inadequate seed quality. However, during the period of vegetative growth, the occurrence of physiological disorders will relate to:

1) **inhibition of growth:** caused by deficiency or incorrect uptake of nutrients (mainly nitrogen) or damage to the root system (inadequate ground moisture, mechanical damage);
2) **chlorosis and yellowing of leaves or discolouration thereof**: the cause may be accelerated degradation of chlorophyll and leaf ageing with nitrogen deficiency or incorrect uptake thereof (lower leaves), or long-term disturbances in the water management of plants (damage to the root system, abnormal air-water conditions);
3) **leaf necrosis:** caused by the die-off of heart leaves - Ca deficiency or as the final phase of leaf chlorosis - due to various reasons;
4) **heart leaf dieback:** the cause is compact soil, variable moisture conditions in the substrate, or calcium deficiency;
5) **large leaves and poorly developed root:** the cause is excessive nitrogen fertilisation;
6) **rusting and discolouration of the root skin** caused by abnormal air-water conditions in the soil;
7) **distortion of roots** visible as:
   - **shortening of the root (barrel-shaped root)** – caused by overly compact soil and insufficient moisture in the deeper layers of the substrate,
   - **forking of roots below the barrel-shaped swelling** – caused by overly compact soil with regulated moisture or damage to the taproot in the juvenile stage,

- **lateral roots on the main root** – caused by rapid changes in soil moisture conditions,
- **root distortion/deformation** – resulting from overly dense sowing,
- **cracking of the storage root or the growth of secondary storage roots** resulting from nitrogen deficiency in the final cultivation period, with abundant irrigation and intensive plant growth;

8) greening of the root head – caused by inadequate covering of the root head with soil (slippage of light soils) and chlorophyll synthesis at the site of root exposure to light.

Measures to prevent the occurrence of these physiological disorders are:

- ***properly prepared soil*** (performing deep loosening, cultivating on ridges with appropriate soil density; proper cultivation technology - earthing up the base of the rosette during the growing season - preventing greening of the root head; application of soil improvers) and controlling pedoclimate (microclimate in the root zone),
- ***use of appropriate plant spacing*****,**
- ***adaptation of the variety to the cultivation period*****,**
- ***application of appropriate pre-vegetation fertilisation and top dressing of plants*** (fertilisation based on chemical analysis of the soil; in case of excess nitrogen, application of potassium fertilisation to reduce nitrogen uptake by plants; after noticing the symptoms of N deficiency (no later than by the middle of the growing period), the use of foliar feeding with nitrogen (calcium nitrate, urea); Ca deficiency - feeding plants with calcium-containing preparations (preventive or intervention),
- ***proper irrigation of the crop*** (uniform irrigation and loosening of the inter-rows after excessive moisture).

III. PROTECTION OF ROOT AND FLAT-LEAF PARSLEY FROM HARMFUL ORGANISMS

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Harmful organisms, i.e. pests (pathogens, weeds), are commonly found in crops, causing large yield losses. Plant protection aims to prevent the reduction and deterioration of yields caused by pests, as well as their transmission and spread to areas where they have not previously been present. Integrated Pest Management, mandatory since 2014, is an important part of Integrated Plant Production. It uses natural biological and physiological mechanisms of plants, which are supported by the rational use of conventional, natural and biological plant protection products and knowledge of harmful organisms; in particular, their biology and harmfulness, in order to determine optimal combating dates. It also takes advantage of naturally occurring beneficial organisms, including predators and parasites, which can be introduced. The essence of integrated plant protection is to obtain high yields of good quality, under optimal cultivation conditions, in a way that does not threaten the natural environment and human health, while maintaining the profitability of production.

In integrated plant protection, non-chemical methods are preferred: agro-technical and biological-mechanical, with the chemical method used to supplement them. Chemical

protection against pests should be carried out in accordance with the principles of Good Plant Protection Practice (GPPP), which results, among others, from relevant European Union directives (e.g. Directive 2009/128/EC of 21 October 2009) and the Plant Protection Products Act of 8 March 2013 (Journal of Laws of 2024, item 63). Plant protection products currently registered in vegetable crops are subjected to thorough testing, in accordance with the rules laid down by the European Union. Stringent requirements as regards the quality of the measures, their toxicology and effects on arable crops and the environment ensure that the recommended measures do not pose a risk to the natural environment, the user or the consumer, provided that they are properly applied. Integrated pest protection must respect the following principles:

- ♦ The need for treatment with a plant protection product should be determined on the basis of the identification of pests and the severity of their occurrence, the threshold of harmfulness, as well as the signalling of the emergence of pests and diseases, and the prediction of the occurrence of weeds.
- ♦ Products authorised for use in the Integrated Plant Production system should be used, in particular those with a short withdrawal period, which remain in the soil for a short time, decompose rapidly and have the least negative impact on the crop, soil and beneficial organisms.
- ♦ It is always required to use products authorised for use on the specific plant and intended to control the specified pest species, and to comply with the recommended doses, timing, and method of use indicated on the label attached to each package of the product. Prior to treatment, the producer is obliged to familiarise themselves with the label and instructions for the product to be used.
- ♦ The agents recommended for the protection of root and leaf parsley are included in the Parsley Protection Programme developed at the Institute of Horticulture – National Research Institute in Skierniewice, as well as in the recommendations of the Institute of Plant Protection – National Research Institute in Poznań.
- ♦ Plant protection products should be used in accordance with the recommendations provided on the label and in a way that does not endanger the health of humans, animals or the environment.
- ♦ Plant protection procedures should be performed in conditions that are most optimal for their effectiveness and in such a manner so as to utilise their biological activity as much as possible, with the simultaneous minimisation of doses and reduction in their consumption.
- ♦ The use of plant protection products should be reduced, among others, by their accurate use only in places where harmful organisms occur, the addition of products to the spray liquid, the use of split doses as well as the adaptation of doses to the developmental stages of the crop, weeds, and soil conditions.
- ♦ An increase in the presence of pests, especially in large plantations, may occur unevenly, so the treatment sometimes only needs to be performed in the pest occurrence area, on

the periphery or in selected parts of the field. In addition, in some years some of the pests do not occur or appear at an intensity that does not require control.

- ♦ Field mapping using modern methods (aerial photos or drones) should be used to determine the signs of damage, e.g. by pests or diseases, the distribution of weeds in a plantation, or to perform treatments only where necessary.
- ♦ Plant protection products differ from one another in terms of their period of activity and persistence in the soil and the environment. This should be taken into account in the planning of subsequent plants cultivated both after the full cultivation period and in the event of an earlier liquidation of the plantation, as a result of winter damage, destruction of plants by diseases or pests and others.
- ♦ Agents with different mechanisms of action should be used to prevent harmful organisms from becoming resistant to the active substances they contain. The alternating application of products results from the need to preserve biodiversity and protect the environment.
- ♦ The effects of plant protection products on harmful organisms and arable crops depend on the occurring pests, the cultivated plant species, as well as their developmental phases, soil and climatic conditions.
- ♦ Herbicides generally work more effectively the higher the temperature, while some insecticides may not work as well or cause damage to the crops being sprayed. It is recommended to spray the plantations during rain-free and windless weather when the air temperature is 10-20 ℃. If the temperature is higher, treatments should be carried out early in the morning (when the crops are in full turgor) or in the afternoon.
- ♦ Chemical treatments should be performed with sprayers ensuring accurate coverage of the sprayed surface with drops of the spray liquid. Herbicides should be applied by means of sprayers equipped with low-pressure, flat nozzle sprayers, while vortex sprayers can be used for fungicides, insecticides and other agents.
- ♦ The spray liquid should be prepared in the amount necessary to spray the planned surface, preferably immediately before the treatment. In the event of an interval in spraying, before starting the procedure, the spray liquid should be mixed thoroughly using a stirrer.
- ♦ After the treatment, the residual liquid should be diluted with water and used up on the surface on which the treatment was carried out or it should be neutralised using technical solutions ensuring the biological degradation of active substances of plant protection products (e.g. biobet).
- ♦ After the procedure, the sprayer should be thoroughly washed, preferably using special agents intended for this purpose, made using phosphates or sodium hypochlorite.
- ♦ Rinse emptied packaging three times with water and pour the remaining liquid into the spray tank.
- ♦ Treatments with plant protection products should only be carried out by persons trained by entities registered by the regional plant health and seed inspector. During the preparation of the products and during the treatments, relevant health and safety regulations must be followed and appropriate protective clothing must be used.

♦ Prior to the use of the product, all interested parties who may be exposed to the spraying of the liquid and who have requested such information should be informed of the above.

LISTS OF MEASURES FOR INTEGRATED PLANT PRODUCTION
published on the website of the Institute of Horticulture - National Research Institute:
http://arc.inhort.pl/serwis-ochrony-roslin/ochrona-roslin/ochrona-roslin-rosliny-warzywne/rosliny-warzywne-wykaz-srodkow

Information on the scope of plant protection and the selection of cultivars, including methodologies of integrated protection of vegetables against harmful organisms, as well as information about the available support systems in pest management decisions, is published on the following websites:

www.gov.pl/web/rolnictwo – Ministry of Agriculture and Rural Development,
www.inhort.pl — The National Institute of Horticultural Research in Skierniewice,
www.ior.poznan.pl — Institute of Plant Protection – National Research Institute in Poznań,
www.gov.pl/web/piorin – The State Plant Health and Seed Inspection Service,
www.coboru.pl — Research Centre for Cultivar Testing in Słupia Wielka,
www.agrofagi.com.pl – Online Pest Warning System - Institute of Plant Protection – National Research Institute in Poznań

The list of plant protection products authorised in Poland is available in the register of plant protection products on the website of the Ministry of Agriculture and Rural Development (MARD) (https://www.gov.pl/web/rolnictwo/ochrona-roslin), and information on the extent and manner of their use in individual crops is included in the labels of the products (https://www.gov.pl/web/rolnictwo/etykiety-srodkow-ochrony-roslin), which can be found on the website of the Ministry of Agriculture and Rural Development, as well as in the packaging of each product. An auxiliary tool for the selection of pesticides is the search engine for plant protection products available at: https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin. Lists of plant protection products approved for integrated plant production are prepared by the Institute of Horticulture - National Research Institute in Skierniewice and available on the Institute's website at: http://www.inhort.pl/serwis-ochrony-roslin/ochrona-roslin/ochrona-roslin-rosliny-warzywne/rosliny-warzywne-wykaz-srodkow; such agents are also marked as IP in the Programme for the Protection of Vegetable Plants Grown in the Field, published by Polskie Wydawnictwo Rolnicze Sp. z o.o. In addition, information on plant protection products for integrated production is published on the Pest Alerting Platform at

https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.

3.1. Prevention in the reduction of harmful organisms of parsley

The technology of growing parsley includes a number of cultivation and care treatments that affect harmful organisms to varying degrees. Negative effects caused by harmful organisms on root and leaf parsley crops can be limited by creating appropriate conditions for the growth and development of the crop, strengthening its defence mechanisms, increasing resistance to pathogens, making it easier for plants to compete with weeds, as well as increasing the population of beneficial organisms. Prevention, which plays a very important role in counteracting harmful organisms, includes elements such as: proper crop rotation, application of appropriate agrotechnics and careful soil cultivation, selection of varieties adapted to local soil and climatic conditions and resistant or tolerant to pathogens, sustainable fertilisation adapted to the nutritional requirements of the crop and soil richness, appropriate sowing times, appropriate plant density, irrigation both in periods of scarcity and high water demand, and careful plant care, prevention of introduction of harmful organisms, protection and creation of favourable conditions for beneficial organisms, application of phytosanitary hygiene measures.

The prevention of the emergence and spread of harmful organisms in crops of parsley entails the use of phytosanitary hygiene measures, which include:

- Careful harvesting of the precursor crop so that crop seeds, weeds, and vegetative organs (e.g. roots, tubers) do not remain in the field. Sprinkled weed seeds increase the supply of weeds in the soil, resulting in an increase in weed infestation, while the seeds of some crops can be a major problem for successor crops, such as self-seeding rape;
- Removal from the parsley field of plant residues infected by diseases of fungal, bacterial and viral origin, thus reducing the occurrence of many diseases and their causes. It is important to remove the infested plant residues immediately after harvest, as they serve as a wintering site for many diseases.
- Fast and accurate covering of crop residues, enabling soil microorganisms to start the decomposition process.
- Avoiding the use of poorly decomposed manure because weed seeds capable of germination and various plant pathogens may be found there. Fertilising the field with manure usually causes an increase in weeds, because not all weed seeds are destroyed in the digestive tract of animals (e.g. white goosefoot, red-root pigweed, common chickweed, couch grass) or do not die during fermentation.
- Manure applied in autumn leads to fewer weeds in the field compared to the spring, as the weeds are destroyed mechanically during autumn or spring cultivation and, in addition, some of the weed seedlings die during the winter. Fertilisation with manure and organic fertilisers may increase the incidence of beneficial organisms.

- Using soil compost that is free from diseases, pests and weed seeds. Materials with pathogens or containing weed seeds cannot be used for the preparation of compost. A compost pile can be covered, thus preventing the laying of eggs by pests (e.g. blowflies, mosquitoes, beetles); weeds present on the pile must also not be allowed to produce seeds.
- Systematic cleaning and removal of plant debris from vehicles, machinery, and tools used for plant cultivation and care to prevent the transmission of harmful organisms (e.g. nematodes, weed seeds, viruses, bacteria, and fungi).
- Preventing weed seeds from entering parsley plantations from neighbouring areas and preventing weeds from releasing seeds on the margins, slopes, and shoulders. This is particularly important for those species whose seeds can be easily carried by wind or animals. In order to prevent weeds from releasing seeds and the transfer of weed seeds or their vegetative organs from neighbouring areas to the parsley plantation, uncultivated areas around the plantation (e.g. margins, ditches, roads) belonging to the same holding should be mowed. Flowering weeds attract pests that inhabit parsley, and their nectar is a source of food, while weed seeds contribute to increased weed infestation of the field in subsequent years.
- Monitoring the occurrence of harmful organisms, including inspections of parsley plantations and identification of diseases, pests, and weeds, as well as determining their severity and area of occurrence. For this purpose, it is necessary to have knowledge of the biology of harmful organisms and their risks to the crop.

IV. WEEDS

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4.1. Occurrence and harmfulness of weeds to root parsley

Parsley is a species that must be carefully weeded to obtain a high yield of good commercial quality. The high sensitivity of this plant to weeds during its growth is due to the long germination and emergence period, slow growth, poor foliage, and low leaf coverage rate at the beginning of the growing season. The harmfulness of weeds is manifested by a decrease in parsley yields, reaching up to several dozen percent, and a decrease in the commercial quality and nutritional value of roots. The greatest threat to parsley is weeds appearing from emergence until the inter-rows are covered by parsley leaves. The harm caused by weeds to this plant varies and depends on the species present, their intensity and date of emergence, the method and date of cultivation, and weather conditions. It was found that the average weight of weeds after 43 days from sowing, on arable soil, was 8.2 t/ha. Weeds grow quickly, make better use of the water and nutrients taken up from the soil, heavily shade young parsley plants and cause significant weakening of parsley growth.

The source of weed infestation in the field is weed seeds located in the soil and transferred from adjacent fields or those located at a considerable distance. Weed seeds may be dispersed: by wind (anemochory), water (hydrochory), animals (zoochory),

spontaneously (autochory) or by humans (antropochory). Parsley is sown, as a rule, in early spring, which affects the weed structure. In the weed population, mainly annual dicot species predominate, and their share usually exceeds 70 %. In early spring, parsley is primarily infested by weed species with lower thermal requirements, needing an average daily temperature of 1-5°C to germinate, such as: white goosefoot, chickweed, shepherd's purse, buck-bindweed, wild mustard, spotted knotweed, cleavers, field pansy, field pennycress, groundsel, deadnettle, and chamomile weeds. Later, there are additional thermophilic species, such as galingsoga, red-root pigweed, black nightshade, or cockspur grass. In some areas, cleavers may appear in larger quantities. Weed emergences usually occur earlier than parsley emergences, especially when this plant is sown early and air temperatures are low.

Many weed species have a broad 'ecological optimum', i.e. they can appear at different times of the growing season, regardless of weather conditions, including before parsley is harvested (secondary infestation). These include: white goosefoot, field mustard, galinsoga, field pennycress, field pansy, common stork's-bill, Persian speedwell (tab. 2). Secondary weeding is less important than primary weeding, but it delays and hinders harvesting, may also cause an increase in the nitrate content in the roots, the development of diseases and pests, and may worsen the conditions for the application of measures against diseases and pests.

Proper protection of parsley against weeds requires knowledge of weed species and methods of their control. Observations of the occurrence of weed species should be conducted in the year preceding the cultivation or in the year of growing parsley.

Table 2. Harmfulness of major weed species for parsley crops

Species – English and Latin name	Harmfulness
1. Dicot weeds	
Geranium (*Geranium* spp.)	**+**
Common fumitory (*Fumaria officinalis* L.)	**+**
Field pansy (*Viola arvensis* L.)	++
Field mustard (*Sinapis arvensis* L.)	++
Common chickweed (*Stellaria media* (L.) Vill.)	++
Common stork's-bill (*Erodium cicutarium* (L.) L'Hér.)	**++**
Deadnettle (*Lamium amplexicaule* L.)	++
White goosefoot (*Chenopodium album* L.)	+++
False mayweed (*Matricaria maritima* L. subsp. *inodora* (L.), Dostál)	++
Annual nettle (*Urtica urens* L.)	++
Persian speedwell (*Veronica* spp.)	**+**
Cleavers (*Galium aparine* L.)	++
Buck-bindweed (*Fallopia convolvulus* (L.) Á. Löve)	++
Field chamomile (*Anthemis arvensis* L.)	++
Chamomile (*Chamomilla recutita* (L.) Rauschert)	**+**

Volunteers rapeseed (*Brassica napus* L.)	**++**
Groundsel (*Senecio vulgaris* L.)	++
Red-root pigweed (*Amaranthus retroflexus* L.)	++
Shepherd's purse (*Capsella bursa-pastoris* (L.) Medik.)	+++
Field pennycress (*Thlaspi arvense* L.)	++
Galingsoga (*Galinsoga parviflora* Cav.)	+++
2. Monocot weeds	
Cockspur grass (*Echinochloa crus-galli* (L.) P. Beauv.)	+++
Couch grass (*Agropyron repens* (L.) P. Beauv.)	++
Foxtails (*Setaria* ssp.)	+

(+++) very high harmfulness; (**++)** high harmfulness; (**+)** low harmfulness or a locally important weed

Note! Proper protection against weeds requires knowing weed species and methods of their control. **It is the responsibility of every IP producer to identify the weed species present in the field intended for parsley cultivation and to record their names in the integrated production notebook.** Observations should be conducted in the year preceding the cultivation of parsley, and for the proper identification of species, the methodology of integrated root parsley protection can be used, which includes photos of weeds in various developmental stages, as well as weed atlases, guides, or special applications with numerous photos of weed species. The methodology is available on the website of the Institute of Horticulture – National Research Institute in Skierniewice at: (http://arc.inhort.pl/serwis-ochrony-roslin/metodyki/metodyki-rosliny-warzywne). In order to facilitate protection of subsequent crops, weed species should also be identified during the cultivation of parsley and their names recorded in the Notebook.

4.2. Non-chemical methods of weed control

Prevention and control of weeds by agrotechnical methods

In integrated weed protection for parsley, agrotechnical methods play an important role. These include, among others, proper crop rotation, preventing the phenomenon of weed species compensation, selection of the appropriate variety adapted to local soil and climatic conditions, careful soil cultivation, fertilisation based on analyses of fertiliser needs of the crop, irrigation in periods of water shortages, and careful plant care.

- Parsley plantations should be established in fields in good condition, with little weed infestation. Fields infested with perennial weeds (e.g. field bindweed, yellow fieldcress, field horsetail) should be avoided, as there are no herbicides effectively controlling these species in the cultivation of parsley.
- Rapeseed stands should not be chosen for growing parsley, because self-seeding of this plant is difficult to combat with the recommended herbicides, and other methods are labour-intensive or expensive.

- Cultivation of parsley after early-harvested crops provides greater opportunities for proper soil preparation and, above all, enables the destruction of weeds through mechanical treatments.
- Weeds must not be allowed to flower and release seeds, as the increased supply of viable seed in the soil results in greater weed infestation in the plantation in subsequent years. Flowering weeds also attract pests that inhabit parsley.
- Cultivation of catch crops or stubble successor crops such as white mustard, winter rye, blue phacelia, oilseed radish and buckwheat. These plants reduce the occurrence of certain weed species.

Note! In order to prevent the release of seeds by weeds and the transfer of weed seeds or their vegetative organs from neighbouring areas to the parsley plantation, **it is compulsory to mow the uncultivated areas around the plantation (e.g. margins, ditches, roads) which belong to the same farm at least twice a year (end of May/beginning of June and end of July/beginning of August).**

Mechanical control of weeds in the cultivation of root and leaf parsley

In vegetable crops, passive tools with angular knives and goosefoot were used for mechanical weed control, most often combined with inter-row string rollers. Such weeders could only be used for inter-row weeding. New technical solutions, currently used in the development of tools, offer broader possibilities for weed destruction. They can be used between the rows, close to the crop, and also to destroy weeds in the plant rows. Such tools include brush weeders, finger weeders, brush and finger weeders, and torsion weeders. Modern and functional weeders usually consist of different weeding elements. Such weeders can be used on parsley plantations, after the emergence of weeds, when they have up to 2-4 true leaves. Until then, from the emergence of parsley, weeders can be used to destroy weeds in inter-rows.

- Before growing parsley, from the delayed sowing date, after preparing the soil, the field can be irrigated, which will stimulate weeds to germinate, and after about 5-7 days, harrowing can be carried out or shallow tillage unit applied, which destroys the germinated seeds and seedlings of weeds, and at the same time prepares the soil for sowing.
- Mechanical and manual weeding can be carried out as early as 1-2 weeks after the emergence of parsley, following the appearance of weeds, preferably after rain or irrigation and once the soil has dried.
- Mechanical treatments should be performed as shallowly as possible, to the same depth in individual treatments (usually 1–3 cm), when the weeds are small and it is more difficult for them to take root.
- The number of mechanical treatments depends on the dynamics of weed appearance and weather conditions. In the cultivation of parsley, it is possible to perform up to 4-5 treatments, and when using herbicides, there is often no need for such weeding.

Thermal weed control

Weeds can also be controlled with flame weeders, burning propane gas from the cylinder. Such a treatment can be performed before sowing parsley, if weeds appear after soil cultivation, or 2-3 days before the emergence of parsley, on the entire area of the field. Weeds treated with high temperatures perish after several days, but this practice does not provide protection against the emergence of new weeds. It is assumed that flame destruction of weeds delays weeding by about 2 weeks. The effect of weed burning treatment is similar to the use of non-selective herbicides with systemic action.

4.3. Chemical weed control

Protection of parsley from weeds should be integrated and based on the use of different methods. The use of herbicides is still the most effective way to reduce weeds in the cultivation of parsley, but different ways of reducing weeds or delaying weed emergence should be taken into account. Due to the very high sensitivity of parsley to weeds, one of the most important tasks is the destruction of perennial weeds. These weeds can be controlled before cultivating parsley with non-selective herbicides with systemic action. These measures destroy almost all species of weeds, with the exception of field horsetail. They are used mainly to control couch grass and perennial weeds. At the time of treatment, weeds should be in a period of intensive growth. Most of these agents are recommended in doses intended for use with 200-300 l/ha of water, although they can also be used in lower doses, with 100-150 l/ha of water. Ammonium sulphate (5 kg/ha) or an appropriate adjuvant may be added to the formulation to increase the effectiveness of these agents. After harvesting precursor crops, these agents can be used until late autumn, if the temperatures are not too low.

Under Article 55 of Regulation No 1107/2009, chemical plant protection products must be used properly, in accordance with the principles of good plant protection practice, as stated on the labelling. Currently registered herbicides undergo thorough testing, in accordance with the rules set by the European Union. Stringent requirements on the quality of the products, their toxicology and their impact on crops and the environment ensure that the products recommended in vegetables do not pose a risk to the environment, the user and the consumer. It is worth noting that herbicides included in the selection for vegetables, like other agents, do not exhibit harmfulness, provided that they are properly used in accordance with the approved label. Observing the instructions for use, such as the right choice of agent, the dose rate, the date of application, appropriate development phases of the crop and weeds, technical conditions of the procedure and other factors, determines the safety of treatments with all plant protection products.

Selection of herbicides in the cultivation of parsley

The selection of herbicides for weeding parsley, as well as the number of treatments, depend on many factors, primarily on the degree and structure of weed infestation, the dynamics of weed emergence, weather conditions, and soil moisture.

Rules for the selection of agents for the protection of parsley

- The use of a plant protection product cannot pose a risk to the health of humans and animals or to the environment.
- Herbicides should be selected according to the weeds present and the degree of infestation. Use herbicides registered and approved for weeding parsley, as recommended on the product label.
- Soil-type herbicides are recommended to be applied on well-growing soil, with an even surface and adequate humidity. On compact, humus-rich soils, the higher of the recommended doses should be used, and on light soils – the lower dose should be used. In some soil types containing very high amounts of organic matter, e.g. peat soils, the efficacy of soil herbicides is very low or non-existent.
- Each product has a specific optimal temperature range in which it is the most effective without posing a risk to the crop. The optimal temperature for most herbicides is in the range of 10-20°C; for some, it is higher, e.g., graminicides should not be used at temperatures above 27°C. During high temperatures, treatments should be carried out in the afternoon or early morning.
- Soil moisture has a considerable impact on the activity of soil-applied herbicides — their effectiveness is reduced in the case of low soil moisture. Air humidity has a greater impact on foliar-applied herbicides. In the case of very low air humidity, the liquid on leaves dries up more quickly and its penetration into plants is limited, whereas the spray liquid may drip off the leaves if there is very high humidity.
- Herbicides should be used during dry weather. A small amount of precipitation after the use of soil-applied herbicides is favourable, while heavy rainfall may lead to flows of the product in soil and even crop damage. Following a foliar application, precipitation may wash the product off the leaves and weaken its activity. The period between the treatment and precipitation varies for different products, and its length is often specified on product labels.
- The addition of adjuvants (auxiliary agents) to the usable liquid of certain foliar and soil herbicides enhances their effectiveness and reduces the consumption of the agent.
- The length of herbicide activity and persistence in the environment should be taken into account when scheduling crop rotation and successor crops.

In the protection of parsley, soil herbicides used after sowing are of primary importance, but they should be supplemented with agents used after the emergence of parsley. Particular attention should be paid to the fact that not all herbicides recommended for growing root parsley can be used in leaf parsley. The method of use of the plant protection product is described on its label. The manufacturer of the product shall be liable for its incorrect operation only if it has been used in accordance with the label. In the case of reduced doses or combined use of agrochemicals that are not included in the label, **responsibility lies with the user**.

The use of reduced doses may lead to the development of resistance to plant protection products in target organisms. Therefore, decisions to use a plant protection product at a lower dose than recommended on the label must be taken with great caution, based on knowledge, experience, and observations or professional advice.
When using split doses of a plant protection product, it is required to adhere to the requirements concerning:

- intervals between individual treatments,
- the maximum number of applications of a certain agent during the season,
- the maximum dose of the plant protection product per ha that may be used during the growing season, **if specified on the product label**.

V. DISEASES

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Proper selection of the location of root and leaf parsley plantations can greatly contribute to reducing the occurrence of diseases of infectious origin. The most dangerous diseases of parsley include: alternaria leaf spot, powdery mildew of Apiaceae, rhizoctonia, sclerotinia rot, grey mould, fusarium wilt of root vegetables, leaf spot and wet root rot.

5.1. List of the most important diseases and their characteristics

In order to detect the first signs of disease early, regular plantation monitoring should be carried out, at least once a week, during the period of potential danger, in particular for the presence of: alternaria leaf spot, powdery mildew of Apiaceae. The observations should be recorded in the Integrated Production Notebook.

a) Fungal diseases

Alternaria leaf spot of parsley - pathogen: *Alternaria alternata*

The first signs of alternaria leaf spot on parsley appear on the oldest leaves and these are brownish-black spots around which the tissues turn yellow, and the leaves wither, brown, and die. With a high intensity of disease symptoms, most of the leaves die. All the leaves are infected. At high humidity, a black coating of fungal spore formation forms on the surface of the spots. Dark brown spots appear on the roots during their storage period. Spores of the pathogen are transferred by wind, water, and on mechanical equipment during maintenance work. The optimal conditions for the development of alternaria leaf spot are a temperature of 20-30°C and high humidity. Infected leaves lose assimilative properties and, in cases of severe infestation, premature drying of the cuticle occurs, resulting in a reduction in the quality and size of the root crop. Dried leaves make it difficult to mechanically harvest parsley. The disease causes the greatest damage in seed plantations, causing the roots to die during the inflorescence formation period. Seeds are also infected, becoming the primary source of infection on parsley plantations (seedling blight) in the first year of cultivation.

Prevention and control

- Sowing vegetable seed of at least standard category.
- Observing plant health in a given growing season at least once a week.
- In order to reduce the occurrence of alternaria leaf spot on parsley, regular application of chemical agents should be carried out. At the time of danger or the appearance of the first symptoms of disease, it is recommended to alternately spray parsley plants with fungicides, with different mechanisms of action, registered for IP, at intervals of 7-10 days.

Powdery mildew of Apiaceae - pathogen: *Erysiphe heraclei*

The first symptoms of the disease are observed on the youngest leaves and petioles. They appear in the form of single, white spots of a floury coating of mycelium covered with small, black spores. When conditions are favourable for the development of the disease (warm days and wet nights), the spots increase in size, eventually covering the entire plant. Infested plants turn yellow and gradually die, which leads to inhibited growth and thus reduces root yield. The pathogen overwinters on the remains of plants in the Apiaceae family. In spring, the disease develops on weeds belonging to this family and the conidial spores produced are carried downstream to nearby parsley crops causing plant infections.

Prevention and control

- Observing plant health in a given growing season at least once a week.
- Protection treatments should commence upon the appearance of individual spots on leaves and leaf petioles.
- At the time of danger or the appearance of the first signs of disease, it is recommended to carry out variable spraying of carrot plants with fungicides, with different mechanisms of action, registered to IP.
- The protection programme should include registered non-chemical preparations (at least one treatment should be performed using such a preparation).
- Protection should continue until harvest, on average every 7-10 days, observing the withdrawal period.
- Plants should not be grown in excessive density.
- Avoid nitrogen over-fertilisation.

Parsley rhizoctonia - pathogen: *Rhizoctonia solani* J.G. Kühn

The cause of the disease is polyphagous organisms that infect more than 300 plant species. It is commonly found in soil in the form of hyphae or sclerotia. On the plantation, symptoms occur on individual seedlings or in patches. Due to the rot at the base of the petioles, spreading from diseased roots, the leaves begin to wither from the bottom, turn yellow, and then die. Usually, in the period before harvesting, watery, brown, rapidly enlarging spots appear on the part of the roots above the substrate. Sometimes the dead tissues are covered with a light brown mycelium. On the roots in the storage room, there are small, flat sclerotia (mycelial mats). Brown-violet spots appear in places of sclerotia,

consisting of dying tissues with a collapsed surface. Usually, rot begins at the site of root damage. The optimal conditions for the development of the pathogen are: a temperature range of 9-12°C and cultivation on light soils with a pH of about 5. The disease usually occurs during the pre-harvest period and during the storage of parsley. It is usually accompanied by wet rot of roots.

Prevention and control

- It is necessary to follow the rules of correct rotation; do not grow parsley on plots previously used for root vegetables.
- Maintain proper hygiene in storage rooms, cold stores, and parsley storage areas.
- For storage, use disinfected box pallets. Avoid temperature fluctuations during storage.

Sclerotinia rot - pathogen: *Sclerotinia sclerotiorum*

The cause of the disease is a polyphagous organism, affecting more than 400 plant species. The disease develops at the base of the petioles or the base of the leaves as dark brown watery spots. As the infection develops, a profuse, fluffy, white mycelium is visible within which black endospore spores (sclerotia) form. Infected leaves turn yellow and gradually die, rotting on the ground. In field cultivation, the primary source of infection is the sclerotia of the fungus, overwintering in the soil or on plant debris. Post-harvest infections most often occur during the harvesting and transport of parsley to storage facilities. The pathogen develops best under conditions of moderate temperature and high air humidity. The disease occurs primarily on farms where parsley is grown without crop rotation. The pathogen of the disease can infest the plants throughout the entire growing season, leading to the rotting of parsley during the storage period.

Prevention and control

- Proper rotation should be observed, avoiding cultivation after root crops.
- Before sowing the crop (about 10-30 days), apply a soil spray with an approved biological product.
- Spraying of plants should be carried out after the appearance of the first symptoms of the disease, with 2-3 treatments at intervals of 10-14 days. It is recommended to perform variable spraying of parsley plants with fungicides, with different mechanisms of action, registered to IP.
- After harvesting, roots should be cooled immediately. Constant temperature and humidity should be maintained during storage.
- Fungicides applied during the pre-harvest period protect plants from disease outbreaks during the storage period.

Gray mould - pathogen: *Botrytis cinerea*

The disease perpetrator is a polyphage infecting a wide range of vegetable plants. The first symptoms of grey mould are watery brown patches on which, as the disease progresses, the characteristic grey dusty coating of the fungus stalks and conidial spores appears. In the later stages of the disease, tiny black sclerotia (the spore form of the pathogen) form on the

surface of the infected parsley root or inside the damaged tissues. Infested parsley rots, creating infectious foci for neighbouring plants. The development of the disease is favoured by precipitation, high humidity and mechanical damage to the plants. Dried and mechanically damaged parsley roots are more easily infected. The spread of the disease is also favoured by a small amount of light, the weakening of plants by other diseases, and a deficiency of calcium and potassium in the soil. The optimal temperature for the development of the fungus is 5-20°C and high humidity (95-100 %), but mass rotting of parsley can occur even at 0°C. Gray mould is most common in the final vegetation period or in the initial storage period of parsley. The greatest losses in yield due to this disease are recorded during the formation of root thickenings and before the harvesting period. The fungus attacks dead or mechanically damaged plant parts. Infested roots are not suitable for storage and consumption.

Prevention and control

- During periods favourable to the development of the disease or when the first symptoms of the disease are noticed, it is advisable to spray parsley plants with fungicides registered for IP.
- Parsley should be harvested in periods of low soil moisture.
- Store roots that are healthy, undamaged and free of soil contamination.
- Maintain optimal temperature and humidity in storage rooms.

Fusarium wilt of root vegetables - pathogen: *Fusarium* Link

On seedlings and young plants, there are symptoms of root rot and growth inhibition. The root system of diseased plants is significantly reduced compared to healthy plants. The leaves start to wither from the bottom, turn yellow, and then die. Under the leaf rosette, brown rot forms on the root, covering the entire perimeter of the shoot. After harvesting the roots, lenticular putrefaction spots are visible on their surface. The spots occur at the site of lateral root growth or mechanical damage. Over time, the spots enlarge into large areas of bruised tissue covering the subcutaneous layers of the root. After some time, the tissues within the spots break longitudinally, and dry tissue rot turns into wet rot. Very often, rotting of the ends of the roots is observed over a length of 1-2 cm. In the longitudinal or transverse section, browning of the stele can be observed. Infection occurs through small wounds on the root or root hair cells.

Prevention and control

- The occurrence of the disease can be prevented primarily by observing a break of several years in the cultivation of parsley (4 years) on the same field.
- Cultivating on very moist soils and in areas with water accumulation should be avoided,
- Deep tillage (with a subsoiler up to 40 cm) should be performed before sowing.
- Treated seeds should be used before sowing.
- Cultivation of parsley on ridges or raised beds and appropriate pre-harvest protection has a significant impact on the health of parsley roots.

- Observations of the severity of the disease should be conducted at the end of the vegetation period and in storage every 7 days.
- Do not allow plantations to flood during cultivation. During watering, favourable conditions are created for the spread of spores.
- The occurrence of the disease is limited by soil pH 6.5-7.0 and the use of nitrate-containing nitrogen fertilisers.
- Disinfect the storage room, box pallets, and tools; ensure a temperature of 0-1°C and air humidity of about 95 % during the root storage period.

Leaf spot of parsley - pathogen: *Septoria petroselini* (Lib.) Desmaz

The first symptoms of the disease are small, round, light brown necrotic spots with a diameter of several millimetres on the leaves. There is a characteristic reddish-brown border around the spots. Over time, the number of spots on the leaves and their size increase. On the surface of the spots, small shiny pycnidia (fruiting bodies of the conidial stage of the fungus) are visible, recessed in the plant tissue. With a high intensity of symptoms, the spots merge, and the leaves turn yellow and die. The development of the disease is facilitated by a temperature of 20-25°C and high air humidity.

Prevention and control

- Sowing vegetable seed of at least standard category. For sowing, use healthy seeds free of *S. petroselini*.
- At least a 2-year crop rotation should be used, and deep ploughing should be carried out after harvesting the parsley.
- Monitor plant health in a given growing season at least once a week.
- At the time of danger or the appearance of the first symptoms of disease, it is recommended to alternately spray parsley plants with fungicides, with different mechanisms of action, registered for IP, at intervals of 7-10 days.
- The protection programme should include registered non-chemical preparations (at least one treatment should be performed using such a preparation).

b) Bacterial diseases

Bacterial soft rot - pathogen: *Pectobacterium carotovorum subsp. carotovorum*

The disease occurs in all areas of parsley cultivation. The source of infection is mainly bacteria living in the soil, sometimes in contaminated water. The paralysis of parsley is determined by the occurrence of injuries, mechanical damage, which are the paths of bacterial ingress and excess free water on its surface. Most often, infections occur during harvesting when cutting the tops and performing other care treatments. The conditions conducive to infection are temperatures in the range of 18-30°C and high humidity, both during the growing season and during storage. The initial symptoms of the disease are small watery spots that rapidly enlarge and cause extensive maceration of the affected tissues. The infected parsley root becomes soft and spongy, and its surface discolours and collapses slightly. Tissue within the affected area takes on a creamy colour and becomes slimy. The

outer surface of the infected parsley root may remain intact, while the inner part turns into a cloudy semi-liquid mush. Over time, cracks appear on the crust, through which the mucilaginous mass rises to the surface. Initially, the infested organs are almost odourless, but the rapidly decaying tissue is colonised by secondary saprophytic bacteria and it is these bacteria that cause the characteristic stinky smell. The bacterium can survive in the field on plant residues of perennial host plants as well as in organic matter in the soil and in the larvae of many insect species. The harmfulness of bacteriosis consists in the rotting of parsley during storage, transport, and trade.

Prevention and control

- Sowing vegetable seed of at least standard category.
- Parsley should be cultivated on soils with regulated water-air conditions, free from weeds and properly fertilised.
- Avoid planting crops in wetlands.
- During the ripening phase of parsley, do not allow the plantation to become weedy, as this maintains high humidity, conducive to infection by bacteria.
- Do not spray plantations in hot weather.
- Parsley must be harvested in dry weather and dried thoroughly immediately after harvesting.
- Avoid mechanical damage to parsley during harvest and transport. Protect parsley from root-damaging pests, such as wireworms.
- Systematically disinfect storage rooms, equipment as well as weighing and packing devices.

Risk thresholds and the manner and date of conducting inspections

In order to ensure effective protection against diseases, information about their occurrence, degree of infestation by their perpetrators as well as an assessment of the potential risks caused by them are necessary. Such information is provided by a properly performed monitoring carried out on the farm, in a specific area, or in the entire country. **Monitoring** is a regular inspection for the occurrence of harmful organisms (pathogens, pests or weeds) on plantations and the changes taking place in them during a certain period of time. In order to conduct monitoring, it is necessary to identify the harmful organism that is subject to observation, and select the method and frequency of observation. The appearance of pests at a severity that threatens arable crops is the moment when a decision to perform a procedure with a plant protection product should be taken.

Computer decision support systems developed for different plant species are used in some countries to decide whether a treatment with a plant protection product is necessary. Prevention and control of pests in parsley crops should be carried out on the basis of signalling of pathogens and programmes for the protection of vegetables (e.g. parsley) developed at the Institute of Horticulture — National Research Institute, published on the Institute's website and in the Online Pest Warning System published on the website of the

Institute of Plant Protection — National Research Institute in Poznań. Communications on current pest risks also facilitate decision-making.

Methods of disease prevention

Preventing the occurrence and spread of harmful organisms in root and leaf parsley crops is associated with the use of **phytosanitary hygiene measures**, which include the following cultivation elements:

- Careful harvesting of the precursor crop so that crop seeds, weeds, and vegetative organs (e.g. roots, tubers) do not remain in the field. Buried weed seeds are a source of increased weed infestation in a field, while the seeds of certain cultivated plants may pose a problem in successor crops, e.g. self-seeding rape.
- Thorough covering of crop residues on the field accelerates their decomposition by soil microorganisms. Residues are a wintering place for certain pathogens and pests.
- Preventing weed seeds from entering parsley plantations from neighbouring areas and preventing weeds from releasing seeds on margins, slopes, or shoulders. This is particularly important for those species whose seeds can be easily carried by wind or animals. Flowering weeds may attract parsley pests while weed seeds are a source of increased weed infestation in the field in subsequent years.
- Systematic observations of root and leaf parsley plantations and identification of harmful organisms, as well as determination of their severity and area of occurrence.

5.2. Non-chemical methods of reducing parsley diseases

Agrotechnical method

Crop rotation and crop sequencing are the basis for maintaining proper microbiological balance and soil health. This is associated with the limitation of the multiplication of soil pathogens. Proper crop rotation is aimed at maintaining and improving soil fertility, as well as providing plants with the right amount of nutrients and creating conditions to reduce weed infestation and the incidence of diseases and pests. Good forecrops for parsley are cereal, legume, brassica, cucurbit, and onion plants. For phytosanitary reasons, parsley should not be grown too often on the same site. A few years of cultivation in monoculture poses the risk of accumulation of dangerous pathogens and pests in the soil, and consequently, deterioration of quality and reduction of parsley yield.

Location of the plantation is an important element in the prevention and spread of pathogens, mainly diseases that pose an epidemic threat, e.g. the culprit of powdery mildew. In order to reduce the incidence of disease threats, shaded sites surrounded by trees, shrubs, close to watercourses and meadows should be avoided. Avoid areas where fog may appear in the morning. Long-term wetting of the leaves is the main condition conducive to infection and the development of infectious diseases.

Timely performance of soil mechanical tillage such as: deep ploughing, cultivating, harrowing or deepening has a significant impact on the elimination of water reservoirs in the

field and improvement of soil structure. It should also be noted that soil-borne pathogens can be transferred on wheels of machinery and growing tools to adjacent fields.

Weed infestation in the plantation promotes the development of many diseases, mainly sclerotinia rot and grey mould. In crops with high weed infestation, there is increased moisture in the lower parts of the plants, shading, and restricted access to water and mineral nutrients. Weed-free plantation means better light access and faster drying of the plant surface.

Regulating the times of sowing and harvesting. Too early sowing into unheated soil usually results in a long germination period. This can exacerbate seedling blight, as pathogens have more favourable conditions for infecting germinating seeds. This should be kept in mind especially during cold, humid weather.

Fertilisation. Proper nutrition of parsley plants has a significant impact on plant health. It is important to use soil and leaf fertilisers based on phosphite compounds. Soil diseases can be limited by organic fertilisation using manure and compost as they introduce beneficial microorganisms into the soil which stabilise the microbiological balance.

Application of phytosanitary hygiene principles. Removal of crop residues and fragments of diseased plants as well as cleaning of equipment used in cultivation is an important preventive element in reducing the occurrence of most vegetable diseases. For many disease agents, fragments of plants lying in the field are a convenient place for wintering.

Cultivation method

In integrated plant protection, an important criterion for the selection of varieties is:

- resistance or tolerance to the most dangerous diseases,
- low susceptibility to adverse climatic factors,
- creating a strong root system,
- ability to make maximum use of nutrients,
- cold tolerance and high storage life.

Biological method

This method is effectively and widely used in vegetable crops under cover, and to a lesser extent in field crops. In the biological protection of many vegetable species, including parsley, antagonistic organisms are recommended, e.g. *Trichoderma asperellum*, *Coniothyrium minitans*, *Bacillus subtilis*, which destroy or limit the development of infectious pathogens of fungal origin.

5.3. Chemical control of root and leaf parsley diseases

Preventive method

Application of measures in the form of seed treatment and application of soil granulates before the appearance of disease agents in the field.

- **Seed treatment -** is a fundamental activity that effectively protects seed material against pathogens and also reduces environmental chemical use due to the low consumption of active substances.

Intervention method

It involves the use of registered and approved fungicides for integrated production at the onset of the first symptoms of the disease on individual root and leaf parsley plants on a specific plantation and/or in the immediate vicinity, or according to the indications of alerting devices.

Characteristics of protection measures used in the cultivation of parsley against diseases

The cultivation of root and leaf parsley in an integrated production system does not preclude the use of fungicides to combat diseases of infectious origin. Such measures shall comply with the following conditions: low toxicity to humans and animals, rapid decomposition dynamics and non-accumulation in the environment, selectivity for beneficial insects, a safe formulation, and a broad spectrum for controlling multiple diseases simultaneously. The withdrawal period is very important. Fungicides used for intervention treatments should have a short withdrawal period during the time parsley reaches consumer maturity. Often, the same product has different withdrawal periods defined for different vegetable species. **Fungicides in the protection of root and leaf parsley should be used with various mechanisms of action and alternately, to prevent the development of pathogen resistance to the applied agents.**

VI. PESTS

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6.1. Description of harmful species, prevention and control

The most common species of pests on root parsley and methods to combat them are described below. These include nematodes: northern root-knot nematode and pin nematode, and insects: carrot fly (order — Diptera), willow-carrot aphid, hawthorn-carrot aphid and carrot psyllid (order — Hemiptera), cutworms (order — Lepidoptera), grubs and wireworms (order — Coleoptera). In addition, rodents are included in this group of pests.

Northern root-knot nematode (*Meloidogyne hapla* (Chitwood))
family: Meloidogynidae
Northern root-knot nematode infests more than 550 plant species, including parsley, carrots, tomatoes, potatoes, many species of ornamental plants, and numerous species of wild dicot plants.
Type of damage. Symptoms of the northern root-knot nematode's feeding are visible on the roots in the form of growths. Infested roots are split, finger-like, and numerous lateral roots

grow from them, forming a bushy root system. Northern root-knot nematode causes the greatest damage to parsley plantations established on sandy and peat soils.

Pest description. The female body is pear-shaped, up to 0.9 mm long. Males are worm-shaped, up to 1.2 mm long. J2 juveniles (invasive larvae), like males, have a worm-shaped body, but are smaller than them.

Biology — an outline. Northern root-knot nematodes are sedentary endoparasites; almost their entire life cycle takes place in the tissues of the roots. In the developmental cycle, there is the egg stage, four juvenile stages, and adults. Females lay eggs into gelatinous egg sacs attached to the back of their bodies. One female is able to lay from 300 to 1,000 eggs. The development period of one generation of this nematode is largely dependent on temperature. The hatching of stage J2 individuals usually takes place at a soil temperature of 12°C, and the penetration into the roots and further development occurs when the soil reaches a temperature of 18-21°C. Under Polish climatic conditions, the development of the first generation of the nematode lasts from 9 to 13 weeks.

Pin nematode(*Paratylenchus bukowinensis* (Micoletzky))

family: Paratylenchidae

This nematode mainly infests plants of the Apiaceae family. Parsley, celery, and carrots are particularly sensitive to its feeding.

Type of damage. Pin nematode is an ectoparasite. Rusting and necrosis are observed on parsley roots damaged by nematodes. The defensive reaction of the plant is the production of additional lateral roots, which, however, are very quickly attacked by nematodes. Injuries caused to the roots by pin nematodes allow pathogens to penetrate, initiating diseases that attack the roots of carrots.

Pest description. The female body is 0.26-0.5 mm long and the male body is 0.3-0.41 mm long.

Biology — an outline. The development cycle of pin nematode usually lasts about 30 days. J4 larvae overwinter in the soil, and in the spring, under the influence of root secretions, they molt into adult forms. A fertilised female lays numerous eggs. After 6-7 days, the larvae (J2) hatch, molting twice to reach stages J3 and J4, respectively. The larvae of stages J2 and J3 can move freely in the soil in search of a host, and when they find it, they feed in one place for a long time, mainly on epidermal cells. Stage J4 larvae are adapted to survive adverse conditions such as overcrowding or lack of a host.

Monitoring and threat thresholds. Before planting parsley, it is best to check whether the soil is free from parasitic nematodes at the turn of April and May, especially northern root-knot nematode and the pin nematode. In the case of the pin nematode, the risk threshold for parsley is 30 individuals in 100 cm^3 of soil (tab. 3), while for northern root-knot nematode, the presence of individual specimens in the sample.

In order to take a sample in the field, we move in a zigzag or diagonal pattern (Fig. 1 a, b, c). From a field or plot of 1 ha, uniform in terms of soil type, terrain, cultivated plant and fertilisation, approximately 40-50 samples with similar volume are taken from a depth of

about 30 cm. Samples are taken with the Egner sampler/stick (Fig. 1.1) or spatula (Fig. 1.2). The substrate taken from all points is gently mixed by hand to standardise the sample. About 1 kg of soil is put into a plastic bag for laboratory analysis. The soil sample prepared in this way is sent to an accredited laboratory for testing for the presence of nematodes. The results of the analysis should be attached to the integrated production notebook.

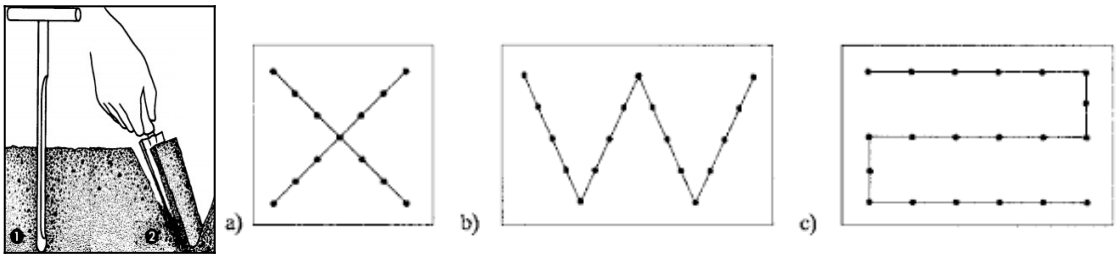

Fig. 1. Sampling scheme

Prevention and control. Nematodes can move with soil and water particles, so agricultural equipment and machinery should be cleaned regularly. The use of healthy seed and planting material reduces the risk of introducing nematodes. The condition for obtaining good yields is to keep the plantations free from dicot weeds throughout the growing season, as most of them are host plants of northern root-knot nematodes. An important element of limiting the population of plant parasitic nematodes is appropriate crop rotation. With northern root-knot nematode, these are, for example, monocot plants, mainly cereals. Setting soil aside and the cultivation of cereals can significantly reduce the population of northern root-knot nematode to levels that do not threaten crops. In turn, the population of pin nematode is reduced by using crop rotation that includes plants from the *Solanaceae*, *Fabaceae* and *Asteraceae* families.

Carrot fly (*Chamaepsila rosae* (Fabr.))
family: Psilidae
It is found throughout the country and inhabits plants of the Apiaceae family, both wild and cultivated: parsley, carrots, parsnips, celery.
Type of damage. The greatest threat is posed by the larvae of the first generation during the period of plant emergence. In this phase, the roots are eaten almost entirely. On older plants, the larvae of the second generation feed in the forming or developed storage roots of parsley from late July to September (and sometimes also in storage rooms), drilling shallow tunnels under the peel, which they fill with their faeces. Often, in damaged areas, pathogenic fungi infect the roots, causing them to rot. Damaged parsley roots are not suitable for storage.
Pest description. The fly reaches a length of 5-8 mm, its body is black and shiny with a conical, sharply pointed abdomen. The head, antennae and legs are yellow. The wings are iridescent, with a span of 13 mm. The larvae are legless, light yellow, cylindrical in shape, up to 7 mm long. The egg reaches a length of up to 0.6 mm and is milky white in colour. Free pupae, known as root maggots, are about 5 mm long, brown, and obliquely cut at the end.

Biology — an outline. Root maggots overwinter in the soil, sometimes also as larvae in parsley stored in warehouses. Two generations develop in one year. The flies emerge in mid-May, when the top layer of the soil reaches a temperature of 12°C. After emerging, the females feed on the nectar of flowering weeds. Carrot fly is a shade-loving insect, which is why it occurs in wooded areas and from there in the morning and late afternoon it flies into fields with parsley cultivation. The flies move at temperatures in the range of 7-25°C, but they show the most activity at temperatures of 12-18°C. Females lay eggs in the soil, near the host plants. The larvae hatch 8-14 days after the eggs are laid and then burrow into the root, where they feed for about 3-4 weeks. Flies of the summer generation appear at the turn of July and August, but under favourable conditions their flight can last up to mid-September. From the eggs laid by flies of this generation, larvae hatch, which feed on the roots of parsley. Then they descend into the soil, where they pupate and overwinter.

Monitoring and threat thresholds. To monitor the flight of carrot fly, yellow sticky boards measuring 20×20 cm are used, which are fixed so that ⅓ of the board protrudes above the tops of the plants. One board should be placed on each side of the field at an angle of 45° to the ground surface. The boards are recommended to be inspected daily, noting the number of flies caught, as insects are effectively caught on the boards in the first 3-5 days. After this time, they need to be changed, as the glue on the boards partially dries. The boards should be set between mid-May and mid-June to monitor the flight of first-generation flies and between mid-July and mid-August to track the flight of second-generation flies.

The risk threshold is catching 1 fly per day for the next 3 days. The risk threshold is determined by the average of at least three of the four boards placed in a field of no more than 1 ha. 3).

Prevention and control. Plantations should not be set up in the immediate vicinity of areas where carrots, parsley, celery or parsnip crops were cultivated the previous year. Plantations located near bushes and trees are most at risk, as fertilised females, after laying eggs on parsley, return during the day to the bushes, where they rest. Females lay the most eggs on plants growing on the outskirts of the field, up to 30 meters into a multi-hectare plantation. Plants growing further away from the shore are much less damaged, as only about 10 % of females travel greater distances to lay eggs. The control procedure is carried out at the beginning of the flight and egg-laying by females, using one of the registered insecticides.

Willow-carrot aphid (*Cavariella* (*Cavariella*) *aegopodii* (Scopoli))

family: Aphididae

It is commonly found on parsley, sometimes with considerable intensity. It is a dioecious species, the primary host is willow, while the secondary hosts are plants of the Apiaceae family—parsley, carrots, fennel, lovage, angelica, and other plants of this family.

Type of damage. The aphids form colonies and feed on the leaves, sucking out the juices. Leaves infested by aphids are distorted, and with time turn yellow. Plants inhabited by aphids are covered with honeydew, on which sooty mould fungi develop. The roots of plants infested by aphids are poorly developed. This aphid is a vector of many viral diseases.

Pest description. Wingless aphids are 1.5-2.8 mm long, green or pink. Winged individuals of the willow-carrot aphid are 1.4-2.8 mm long, green or yellow green with a black spot on the back. Eggs are black.

Biology — an outline. Eggs overwinter on different species of willows. In early spring, aphid larvae hatch and feed on young willow shoots. Several generations of wingless aphids develop on them. When the tissue of willow shoots begins to harden, winged individuals change host. They are transferred to parsley and other plants of the Apiaceae family, on which successive generations of aphids develop. In autumn, winged aphids appear, which return to the winter host.

Monitoring and threat thresholds. From mid-May, it is necessary to inspect the leaves of plants for aphids. Monitoring should be conducted regularly, at 7-day intervals for 3-5 weeks. The hazard threshold is on average 25 aphids per plant.

Prevention and control. Parsley plantations should not be established in the vicinity of willows and plants of the Apiaceae family. After the appearance of the first aphids on the plantations, it is necessary to perform a spraying procedure using the agent recommended for the control of these insects on parsley.

Hawthorn-carrot aphid (*Dysaphis* (*Dysaphis*) *crataegi* (Kaltenbach))

family: Aphididae

It is a dioecious species; the primary host is hawthorn, while the secondary hosts are Apiaceae plants—parsley, carrots, and other plants of this family.

Type of damage. Aphids form large colonies at the base of the leaves and on the root neck, resembling a 'coat,' tightly covering the ground surface around the plants. As a result of sucking the juices, root growth is inhibited, and the foliage undergoes discolouration and distortion. In addition, aphids excrete a sticky substance called honeydew, which covers the leaves of parsley. The honeydew forms the basis for the development of sooty mould fungi covering the leaves with a black coating.

Pest description. Wingless parthenogenetic aphids developing on parsley are 1.4-2.5 mm long, yellow-green to grey-green, slightly dusted with waxy secretion. Winged parthenogenetic aphids are 1.4-2.5 mm long, grey-red in colour with a black pattern.

Biology — an outline. This aphid winters in the egg stage, in the crevices of the bark of branches and hawthorn trunks. The aphids of the spring generations feed on the leaves of hawthorn by sucking the juices. Damaged leaves curl at the edges, taking on a reddish colour. Appearing from mid-May, winged aphids migrate to Apiaceae plants, including parsley. During this time, aphids can cover a distance of up to 1 km. In field conditions, the aphid can produce from 3 to 9 generations. In autumn (September), winged individuals return to hawthorn, where the females lay eggs, placing them under the bark.

Monitoring and threat thresholds. In order to detect aphidsfrom the beginning of May, the plants should be inspected, paying attention to the appearance of the leaf bases and the soil around the plants. Monitoring should be conducted regularly, at 7-day intervals until mid-June. The threshold of danger is the finding of 25 aphids on one plant.

Prevention and control. Plantations should not be established in the vicinity of hawthorn and plants of the Apiaceae family. After observing the first aphids at the base of plants in an area exceeding 10 % of the plantation area, it is advisable to spray parsley with one of the preparations registered for the control of aphids in this crop. Since this aphid is not evenly distributed over the entire area of the field, the treatment should be limited to the areas where it occurs.

Carrot psyllid (*Trioza apicalis* (Zetterstedt)
family: Triozidae
The host plants of this bug are parsley and other plants of the Apiaceae family.
Type of damage. Adults and larvae feed on the leaves, sucking the sap from them. Inhabited leaves curl, and the plants are stunted. Carrot psyllid poses the greatest threat to young plants, especially during warm, sunny, and moderately humid weather.
Pest description. Adults are about 3 mm long, light green or yellow-green in colour. The front wings are colourless or light yellow with yellow, sometimes brownish, venation. The larvae have a flattened body up to 2 mm in length.
Biology outline. One generation grows in a year. Adults usually overwinter on coniferous trees, mainly on spruces and wild carrots. They fly to parsley plantations in May. Females lay eggs on the edges of the leaves, where the larvae also feed.
Monitoring and threat thresholds. The presence of adult insects on parsley plantations should be monitored using yellow sticky boards, which are recommended to be placed in May on the outskirts of the field. After capturing adult specimens of carrot psyllid on the boards, the plants in the field should be inspected for larvae visible on the leaf edges. Plants are inspected when they are in the 3-4 leaf stage, at weekly intervals until larvae are detected. The hazard threshold is not specified, but the capture of adults on boards or the detection of larvae on more than 3 % of plants is the basis for the decision to undertake control measures.
Prevention and control. Plantations close to coniferous trees and last year's parsley or carrot plantations should be avoided. Once the hazard threshold has been reached, a spraying procedure should be carried out using a product registered for the control of these insects on parsley.

Cutworms - larvae of moths from the Noctuidae family
family: Noctuidae
The greatest threat to vegetable crops, including parsley, is posed by the **cereal cutworm**, which is the most numerous. The following can be present in slightly lesser intensity: **heart and dart**, **dark sword-grass** and **black cutworm**. All agricultural species are polyphagous, feeding on many species of cultivated and wild plants from different botanical families.
Type of damage. Younger caterpillars feed on the above-ground parts of plants, while older ones hide in the soil during the day, where they feed, damaging the underground parts of plants. At night, they come to the surface and cut the plants, causing them to topple over.

The caterpillars then pull the leaves into their hiding places or nibble them off. In spring, one caterpillar can destroy several plants, which, when numerous on the plantation, causes thinning of the sowing and the formation of so-called bald patches. In the summer, until the first frosts, one can again observe the damage caused by cutworms. They then damage the roots of parsley by gnawing through them in all directions or by creating deeper or shallower irregular holes.

Pest description. The moths have a wingspan of up to 45 mm. The front wings are darker than the rear and feature patterns in the form of round, oval, and kidney-shaped spots, as well as bands. Caterpillars of: cereal cutworm are 45-50 mm long, dark olive with a greenish tint and darker lines along the body; heart and dart are 35-50 mm long, brown-grey, with a bright line along the body; black cutworm are up to 35 mm long, grey-green or brown; dark sword-grass are up to 50 mm long, dark green, matte, with a reddish line on the dorsal side. The pupa is closed and reddish-brown.

Biology — an outline. Depending on the prevailing weather conditions, cutworms can develop 1-2 generations per year. Caterpillars or pupae overwinter in the ground (up to about 20 cm). The caterpillars leave their winter hiding places and start feeding in April when the soil temperature is above 10 °C. They then descend into the soil to pupate. Butterflies fly out in late May to early June. They are active at dusk and at night. Females lay eggs in the soil or on plants. Caterpillars hatch after 5-15 days and feed on the plant during the day. The older ones are mostly active at night, and during the day they hide underground.

Monitoring and threat thresholds. The risk assessment by farmers should be carried out before plantations are established, preferably in the autumn of the year preceding the crop, when there is still the possibility of using agrotechnical control methods. The monitoring is best done during ploughing or harrowing. The threshold of danger is the detection of 4 caterpillars on an area of 1 m^2 of field. During the growing season from the beginning of May to the end of September, the flight of moths (primarily the cereal cutworm) should be monitored on the parsley plantation using pheromone traps. Traps, 2 per hectare, should always be placed above the tops of the plants. They should be monitored at least once a week, each time noting the number of moths to determine the optimal timing of the procedure. In addition, **during the growing season of parsley, the plants should be inspected for the presence of caterpillars at least once a week**. Finding 1 caterpillar per 1 linear meter of row **during this period** is the basis for performing a countermeasure.

Prevention and control. The appropriate agrotechnics are the basic method of reducing the number of cutworms on arable crops. Immediately after harvesting the precursor crop, it is recommended to carry out a shallow tilling, and in the autumn a deep ploughing, because during these treatments a significant part of the caterpillars and pupae are killed. In areas where owlet moth larvae have been found, idle land should be ploughed as it offers them excellent breeding conditions. During the growing season, flowering weeds, which are a source of food for butterflies, should also be destroyed on and near the plantations. For the control of caterpillars, it is recommended to use biological preparations first. Chemical combating consists in spraying the insecticides registered to fight those pests. Due to the

local nature of black cutworms, the first treatment can be limited to areas where plant damage has been found. Treatments should be performed in the evening.

Wireworms - larvae of Elateridae beetles
family: Elateridae
On parsley plantations, the following may occur: soil beetle, darking beetle, metallic flea beetle, and black flea beetle.
Type of damage. The larvae known as wireworms are harmful, as they feed on the roots of parsley, creating holes and tunnels in them. If seedlings and young plants are damaged, they dry out. Damaged areas caused by wireworm larvae are infected by bacteria and fungi, resulting in the tissue in these areas rotting. Parsley is not suitable for storage. Wireworms cause much more damage on moist soils than on dry ones.
Pest description. Beetles have an elongated body, with lengths ranging from 8 to 15 mm. The wing covers are furrowed. A characteristic feature of beetles is the ability to jump when they are on their back (with the use of their jumping mechanism). The larvae of click beetles have a body covered with a hard chitinised cuticle, yellow or brown in colour. They grow up to 25 mm in length.
Biology. The development of one generation, depending on the species, takes 4-5 years. Click beetles overwinter in the soil as adults or larvae. In the spring, the beetles come to the surface of the soil and, after fertilisation, lay eggs in its top layer. Larvae hatch from eggs and undergo their entire development in the soil, feeding on the underground parts of plants, after which they pupate.
Monitoring and threat thresholds. The assessment of threat from larvae should be carried out before sowing the seeds, preferably in the autumn of the year preceding the crop, when agrotechnical control methods can still be applied. For this purpose, 16 samples measuring 25 × 25 cm and approximately 30 cm deep should be taken from various locations in a 1-hectare field, resulting in an area of 1 m^2. The samples taken should then be sieved and the wireworms counted. Detection of 5 wireworms in 16 samples over a 1 m^2 area is the threat threshold.
Prevention and control. Treatments that significantly limit the number of wireworms include shallow tilling, deep pre-winter ploughing, and cultivating. They damage the bodies of insects and also throw larvae onto the surface of the soil, where they are killed by being eaten by birds or as a result of drying. It is also recommended to include plant species that are not very attractive to wireworms in the rotation such as mustard or buckwheat, rape, flax, peas, and beans. If it is possible, introduce spatial isolation from meadows, wasteland, or root crops, which can be an indirect source of the spread of these pests. On smaller areas or under covers, food traps buried in shallow pits between rows of plants may be used. Potato pieces can be used as bait. The traps should be inspected every few days and the wireworms caught should be destroyed.

Grubs – larvae of beetles from the Scarabaeidae family

family: Scarabaeidae

The most damage to vegetable crops is caused by beetle larvae: **May beetle, June beetle** and **garden chafer.**

Type of damage. Grubs feed on underground parts of plants throughout the growing season. They damage the roots by biting out holes of irregular shape. They can also destroy seedlings and young crops. Most damage is caused by the larvae of the older stages, which are very voracious. Beetles, on the other hand, feed on aerial parts of plants.

Pest description. The body of the grubs is white, arched, with a brown head, a thickened blue-stained end, and three pairs of legs. The larvae of garden chafer and June beetle are smaller (approximately 20 mm), while those of the May beetle are larger (approximately 50 mm). May beetles are 20-30 mm long, have a black pronotum and brown wing covers, with white triangles on the sides of the abdomen. June beetles are 15-20 mm long, their elytra are light brown and covered with dense light hairs. Adult garden chafer beetles are 8-12 mm long, with a metallic green pronotum and rusty brown elytra covered with hairs.

Biology — an outline. Development of the larval stages in beetle usually takes 4 years, in the June beetle 2 years, and in the garden chafer – 1 year. Beetles and grubs winter underground. May beetles appear in massive numbers from the end of April to the end of May, and those of the June beetle and the garden chafer — in June and July. 3 to 6 weeks after the eggs are laid, grubs hatch which first feed in clusters and then disperse into the soil. Once the larvae reach the L4 stage, which usually happens at the end of summer or autumn, they descend deeper below the surface of the soil, where they pupate.

Monitoring and threat thresholds. The risk assessment of the larvae shall be carried out in the autumn of the year preceding the crop, when agrotechnical control methods may still be used. For this purpose, 16 samples measuring 25 × 25 cm and approximately 30 cm deep should be taken from various locations within a 1-hectare field, resulting in a total area of 1 m^2. The samples shall then be sieved and the grubs counted. The threshold of danger is the detection of 5 grubs in 16 samples on an area of 1 m^2. **During the growing season, it is necessary to inspect the plants in several locations, paying attention to the appearance of the root.** The danger threshold is the finding of 1 grub per 1 linear meter of the row.

Prevention and control. The basic method of reducing the number of grubs is properly conducted agricultural engineering procedures. As in the case of wireworms: shallow tilling, deep pre-winter ploughing, and cultivation significantly reduce the abundance of larvae in the soil. They damage the bodies of insects and also bring larvae to the surface, where they are killed by being eaten by birds or as a result of drying. It is also recommended to include in crop rotation plant species that are not nutritionally attractive to grubs, such as mustard and buckwheat. During the vegetation period, after exceeding the threshold of danger, a procedure for spraying or watering plants with biological agents may be implemented. If possible, introduce spatial isolation from meadows, wasteland, or root crops, which can be an indirect source of the spread of these pests.

Rodents

High rodent numbers are to be expected if plantations are located near fallow land, wasteland and neglected drainage ditches. The lack of predatory birds and mammals and untimely agrotechnical treatments also contribute to the mass appearance of these pests. An increase in rodent damage occurs during a dry, warm, long autumn and after a snowy winter without thaw or frost and a warm spring.

In parsley, the greatest damage can be done by the **field vole.** It winters in burrows built on idle land, in field trees and on the edges of forests. It is most abundant on light, warm soils. It feeds on plantations in autumn. Can cause damage to mounds. The **European water vole** builds burrows in compact and moist soils. In autumn, in search of food, it migrates from the waters to the plantations. Damage can also be done by: **house mouse**, **striped field mouse.**

Prevention and control: Losses caused by rodents in the field can be reduced by eliminating wasteland, ploughing fallow land, and mowing grasses on margins and ditches. In addition, it is necessary to observe the timely performance of agrotechnical procedures (shallow tilling, disc harrowing, deep pre-winter ploughing).

For predatory birds at the edge of the field, poles about 2-3 m high with a crossbar at the top should be placed. At least 1 pole should be set up for 5 ha plantations and several for larger ones. Birds sit on the pole and look out for rodents.

Table 3. Thresholds for the most important pests of root and leaf parsley*

Pest species	Risk threshold	Monitoring and control deadline	Harmful stage
Pin nematode*	30 individuals in 100 cm^3 of soil	before establishing the plantation	larvae and adults
The carrot fly	catching 1 fly per day for 3 consecutive days on 3 to 4 yellow sticky boards on the plantation	May July — August	larvae
Willow-carrot aphid	first colonies of aphids on cotyledons and first leaves	period of emergence	larvae and adults
Cutworms	4 caterpillars per 1 m^2 of cultivation	before planting (autumn)	caterpillars
	1 caterpillar per linear meter of row	vegetation period of parsley	
Larvae of Elateridae beetles - wireworms	5 wireworms per 1 m^2 of crops	before planting (autumn)	larvae
Beetle larvae of the Scarabaeidae family - grubs	5 grubs per 1 m^2 of cultivation	before planting (autumn)	larvae
	1 grub per 1 linear meter of row	vegetation period of parsley	

*Hazard thresholds: for the pin nematode are given according to Brzeski M.W 1993, and for harmful insects - according to Szwejda J. 2015

6.2. Methods for monitoring pests in the cultivation of root and leaf parsley

Monitoring the presence of pests on plantations is a very important element of integrated plant production. It is used to detect hazards in good time, assess them based on knowledge and own experience, and decide how to reduce the population of phytophagous insects. The basis for the monitoring is direct observation of plants for the presence of pests (eggs, larvae, pupae or adults) or damage caused by them.

One of the most widely used methods of pest monitoring is **the visual method,** which consists of inspecting plants on plantations, during which it is possible to identify pests on the basis of their appearance or the damage they cause. This method is also helpful in determining the presence of, among others, aphids and beneficial fauna. For the correct identification of organisms directly on the plantation, various types of magnifiers are very useful (with a minimum magnification of 3-5, and preferably 10-20 times)

To signal the appearance of the carrot fly on parsley plantations, **yellow boards** are used. Their disadvantage is the simultaneous capture of other, numerous insects (including beneficial ones), and the need to identify the captured species.

Traps containing various chemical substances such as attractants, stimulants, or pheromones are easier to use and more effective in catching pests (the insect's ability to react to odours is utilised). The simplest olfactory traps are food traps. Potato or carrot pieces buried in soil at a depth of 10-15 cm every 2 m effectively attract wireworms, grubs and cutworms.

Pheromone traps are used to precisely determine the dates of plantation threat by cutworms. Currently, pheromone traps are available for catching agricultural pests – (cereal cutworm, black cutworm, heart and darts, dark sword-grass) and cabbage moth. The traps are checked and the insects caught are counted on fixed dates, usually twice a week. The use of pheromones for signalling enables economically justified procedures to be carried out.

In order to determine the abundance of pests living in the soil, it is recommended to take soil samples of an appropriate size. This method should be widely used in parsley growing areas threatened by grubs and wireworms.

In order to monitor the nematodes in the soil, soil samples and plant roots are taken from the plantation and sent to a specialised accredited laboratory that will determine the presence and abundance of parasitic nematodes in relation to plants, including northern root-knot nematode and the pin nematode.

6.3. Indirect methods of pest control in integrated protection of root and leaf parsley

One of the basic assumptions of integrated protection of root parsley against pests is the implementation of preventive measures, based primarily on **agrotechnics**.

Timely implementation of **agrotechnical procedures** (including ploughing, cultivating, harrowing, ridging) helps control pest population. Deep ploughing destroys a significant percentage of grubs, wireworms, cutworms, and carrot fly pupae. It must be remembered

that compacting the soil with heavy machinery is conducive to infestation by nematodes; they can also be transferred on the wheels of machinery to adjacent fields.

In pest protection, properly applied **crop rotation** is a fundamental element in reducing the number of pests, particularly soil pests (cutworms, grubs, and wireworms). It also has a limiting effect on harmful insects that undergo their development cycle at the foraging site or in its immediate vicinity, including the carrot fly. Introduction to the rotation of non-host plants is an important element in limiting the population size of plant parasitic nematodes. With northern root-knot nematode, these are, for example, monocot plants, mainly cereals. Setting soil aside and the cultivation of cereals can significantly reduce the population of northern root-knot nematode to levels that do not threaten crops. In turn, due to the risk of pin nematode in crop rotation, plants from the Solanaceae, Fabaceae, or Asteraceae families should be included.

Equally important is maintaining **spatial isolation** from crops inhabited by the same species of pest, e.g. carrots, celery, parsnips, on which carrot fly larvae also feed. For this reason, it is also not recommended to locate parsley crops in the immediate vicinity of perennial plantations of clover, alfalfa, and other nectar-bearing plants that attract pests with the colour of flowers and nectar. After satisfying their nutritional needs (nectar and water), females, including the carrot fly and cutworms, lay eggs en masse on nearby crops, which are host plants for their larvae. In addition, long-term plantations provide an excellent shelter and food base for soil pests. It is also inadvisable to locate parsley plantations in close proximity to field trees and shrubs. Carrot root flies are shade-loving and avoid sunny and airy places. Also, it is necessary to avoid establishing parsley plantations near primary hosts, on which pests overwinter and on which spring generations develop, e.g. willow-carrot aphid (winged individuals can fly from willow to parsley). The presence of weeds in the fields promotes more intensive infestation of root parsley crops by pests. Some species of weeds may offer a substitute source of food for pests or a place of shelter and wintering. Flowering weeds are also a source of food for adult flies (carrot fly) and butterflies (cutworms).

Fertilisation should be based on a soil analysis of the nutrient content to meet the nutritional requirements of the plants. However, nitrogen over-fertilisation of plants should be particularly avoided, as it increases their attractiveness to pests, especially aphids, and they are therefore more likely to be inhabited by them. In turn, phosphorus and potassium fertilisation promotes the strong development of mechanical tissue and hinders pests from feeding.

6.4. Direct methods of pest control in the cultivation of root parsley

Mechanical method

It can be used in the protection of crops grown in small areas. It involves collecting or removing pests from plants or their surroundings. In order to reduce the damage caused by wireworms, food baits can be laid out. Trapping nets, self-traps, and non-woven fabric covers may be used to catch moths of the Noctuidae family and to protect plants from the cabbage root fly.

Chemical method

The decision to use zoocides should be made based on hazard thresholds determined through visual inspection of plants or the capture of harmful species using tools designed to signal their presence. Therefore, it is necessary to systematically monitor the plantation.

When engaging in integrated production, products with as short a withdrawal period as possible should be used, especially in the case of interventions carried out when vegetables achieve consumption maturity. Among the zoocides used for pest control, the preferred ones include biological and selective measures, i.e. those which impact specific groups of organisms. Biological plant protection products must be used at least once per season (mainly before harvest), which should be confirmed by the purchase invoice of the product.

Rules for use of zoocides

Among zoocides used in pest control, priority is given to biological and selective agents, i.e. those that act on a specific group of organisms. Treatments against aphids should be carried out within 10 days after the appearance of the first aphids on plants—after this period, their natural enemies appear, for which insecticides can be deadly.

All plant protection procedures must be performed in optimal conditions for their effectiveness and in a way that maximises their biological activity, while minimising the doses. Due to environmental protection and the need to preserve biodiversity, the repeated use of the same active substances on the same harmful organism should be avoided so that a 'compensation' phenomenon or immunity does not occur. Another method for limiting the amount of the plant protection product being used is precise, spot application, i.e. only at the locations where pests exist.

When performing the procedure, the air temperature for most measures should be above 18°C, but not exceed 24°C. On days with high temperatures, the procedure should be performed in the early morning, when the plants are in full turgor, or in the late afternoon, not only for the sake of effectiveness but also due to the possibility of phytotoxicity. In addition, treatments with plant protection products should be carried out at times when pollinators are not active.

Herbicides should be used in accordance with the recommendations given on the label and in such a way as not to endanger human health, animals, or the environment.

6.5. Actions aimed at the protection of beneficial organisms

- The use of plant protection products based on the actual threat to crops from pests should always be assessed on the basis of monitoring their occurrence and risk thresholds (if they are developed for a given pest).

- Avoidance of insecticides with a wide spectrum of activity and their replacement with selective products.
- Abandonment of control measures in the case of a small pest population, when it does not pose the risk of significant yield reduction, and particularly when numerous beneficial organisms are present in the crop.
- Application of treatments on the edges of the field or only at specific points, if the pest is not present
  on the entire surface of the crop.
- Leaving margins, inter-field refuges and other ecological sites in the agricultural landscape because they host multiple species of beneficial insects.
- Supporting the presence of pollinators around vegetable crops by leaving or creating food-rich areas for them, such as flower strips, as well as places of refuge and nesting, such as **mason bee houses and bumblebee huts or mounds, with at least 1 per 5 hectares, and in the case of larger plantations, several units**.
- Performing plant protection treatments during hours when bees are not active due to the time of day or weather conditions. Provide appropriate protection to hives in a situation where the spray liquid can penetrate inside. Bees are protected by law, and therefore producers causing the death of bees in an unintentional or purposeful manner are subject to financial punishment. Control over the correct use of plant protection products is exercised by the provincial plant protection and seed inspectorates, which accept reports of bee poisoning and conduct proceedings obliging the producer to cover losses. Poisoning of mothers of wild bees (bumblebees) and female solitary bees (e.g. mason bees) in spring, when they are nesting and breeding, is particularly dangerous.
- Creation of appropriate conditions for the presence of birds of prey by installing perching poles.

VII. HARVESTING AND STORAGE OF ROOT AND FLAT-LEAF PARSLEY

Dr Maria Grzegorzewska

The edible parts of parsley are the roots and leaves, although for use as leaves, special varieties that do not produce storage roots are generally grown. Root parsley belongs to durable vegetables, while leaf parsley belongs to perishable vegetables. The collection and methods of storing roots and leaves are different.

7.1. Factors affecting the storage of root parsley

In order to ensure the supply of parsley to the market in the winter-spring period, part of the production should be directed to storage. These should be roots of high quality and storage durability. When planning the storage of parsley, it is necessary to choose varieties with a high storage capacity and, during cultivation, observe the correct date for sowing, fertilisation, irrigation, and protection against diseases, pests, and weeds. Harvesting is done when the parsley is fully grown but not overripe. Well-developed roots store better than

poorly grown ones, as well as better than overgrown ones with spongy flesh and empty spaces. Parsley is more resistant to low temperatures than carrots and celeriac and can therefore be harvested a little later (in the second half of October). As with other root vegetables, harvesting should be carried out in dry weather, as wet roots do not store well. In addition, the harvest should be carried out carefully and gently, so as not to damage or bruise the roots. With manual harvesting, root selection is carried out in the field, eliminating diseased, damaged, and rotten specimens. When using mechanical harvesting, the machines should be adjusted so that the roots are not damaged when cutting the tops and are not bruised when falling onto the trailer or into the pallet box (the height of the root drop should be as small as possible). These damages are the cause of increased decay during storage. On large plantations, top lifting harvesters are most often used that uproot and pull parsley by the leaves. Then the tops are trimmed and the roots loaded onto trailers or into crates. After harvesting, the roots should be cooled as soon as possible and protected from wilting.

Root parsley is stored similarly to carrots, but usually with a worse result, because the roots show greater susceptibility to rotting. The conditions recommended for storing root parsley are a temperature of 0-1°C and a relative air humidity of 97-99 %. In such conditions, this vegetable can be stored for 6-7 months. It should also be remembered that, as with other root vegetables, when storing parsley at a higher temperature (2-4°C), the relative humidity of the air should be reduced to approximately 95% to prevent root rot. It is not recommended that parsley be stored together with apples or pears (species secreting large amounts of ethylene) due to the acceleration of root ageing processes. So far, there are no recommendations for storing root parsley in a controlled atmosphere.

7.2. Methods of storing root parsley

Leaving parsley in the field

In areas with mild winters and heavy snowfall, parsley can be left in the field (as it grew) and collected only in spring. In autumn, plants are ridged to protect the roots from freezing, while in winter, in the event of severe and prolonged frosts, a straw cover is applied.

Storage in mounds

One of the ways of storing root parsley in Poland is heaping. For parsley, as well as for carrots and root celery, narrow, recessed mounds with a width of 40-50 cm and a depth of 50-60 cm are recommended. Due to the poorer storage life of parsley, it is recommended to cover the roots with damp sand or soil. This ensures better conditions, and at the same time, in the event of root infestation, it protects against the spread of rot. To allow the roots to cool, after filling, the mound is covered with a thin layer of earth (2-5 cm) and left until the temperature in the mound decreases to 1-2°C. After cooling the roots, before the onset of frosts, a winter cover is applied. The first layer of soil is thickened to 10 cm, then a layer of straw (10-15 cm) is spread, and again a layer of soil about 20 cm thick is added. This cover protects the stored roots from freezing during the winter and from a rapid increase in

temperature in the spring months. If the temperature drops significantly for a longer period of time, the mound must be covered with more straw or other insulating materials. It should be remembered that during the cooling of the roots, as well as their storage, the temperature of the vegetables in the mound should be regularly checked, using mercury or electronic mound thermometers for this purpose. Any increase in temperature above the optimal level indicates that putrefaction processes are taking place. In such a situation, the unloading of the mound should be commenced without delay.

In practice, one can also encounter wider mounds that are only partially recessed or superficial. The method of covering and controlling the conditions in wider mounds is the same as in narrow mounds (40-50 cm).

Storage in storage facilities

Parsley can also be stored in traditional storage facilities, packed in boxes with a capacity of approximately 300 kg or heaped in piles. It is recommended that the layers of roots in the piles be covered with damp sand. The results of storing parsley in storage rooms depend on the temperature and humidity maintained during storage.

Storage in cold stores

Parsley is stored in refrigerated chambers in pallet boxes with a capacity of about 300 kg. Under optimum air temperature and relative humidity conditions, parsley can be stored for 6 to 7 months. As with other vegetables, maintaining optimal conditions throughout the chamber is possible thanks to the appropriate arrangement of the box pallets, allowing proper air circulation. High relative air humidity in the cold rooms can be ensured by using air humidifiers. The lining of crates or covering entire blocks of pallet crates with polyethylene film can also be used. Some manufacturers leave an admixture of soil in the boxes, which is to protect the roots from excessive wilting. To ensure good air circulation in the refrigeration chamber, the pallet boxes should be placed at an appropriate distance from the walls and there should be free space between the adjacent rows of pallet boxes. The distance from the wall where the air cooler is installed to the first pallet should be 30 cm, between pallet loads and side walls – from 10 to 15 cm. The distance between the pallet loads and the wall in which the entrance door to the chamber is located should be between 30 and 50 cm. Air coolers should not be installed above the door of the cold store, as each opening of the door results in an influx of warm air containing more water vapour. This air entering the chamber causes ice to form on the cooling fins, which leads to a decrease in their efficiency and requires more frequent defrosting.

Refrigeration chambers, with an indirect cooling system, ensure that the temperature is maintained at a constant level as well as high relative humidity of the air. This is particularly important for maintaining good root firmness and better resistance to diseases. This system is slightly more expensive than the one commonly used in practice (with direct cooling), but it is more suitable for storing vegetables requiring high relative humidity.

7.3. Factors affecting the storage of parsley

The marketed types of parsley include parsley with curly leaves and flat leaves. The first type is most often used to decorate dishes, while the second type is used to season them. For good growth and development, parsley requires humus soil with a large water capacity. Parsley is ready for harvest when the plants have reached at least 15 cm in height, although flat-leaved plants can grow up to 30–35 cm. When harvesting parsley for the fresh market, it is cut by hand with a knife at a height of about 2.5–3.0 cm above the surface of the ground. During the season, several harvests are made on the same plantation approximately every 30 days, because under favourable conditions new leaves quickly grow back. If the parsley is tied into bunches directly on the field, selection must be carried out so that only green, well-grown leaves end up in the bunches, while damaged, yellow, and yellowing ones are rejected. If parsley is packed in the plant, the leaves are usually first washed and then non-commercial leaves are removed from the sorting and packaging line. It is important that the parsley, after harvest, is cooled as soon as possible in order to limit respiration and other biological processes. Cold water can be used for this, already during washing, or forced air cooling in the refrigeration chamber or vacuum cooling can be applied. It is common practice to pack parsley leaves in ice, which ensures a low temperature in the package as well as high air humidity. The optimal storage conditions for parsley are a temperature of 0°C and a relative humidity of 98-100 %. Leaf parsley is very sensitive to ethylene, and even a very low concentration of this gas in the atmosphere accelerates the yellowing and ageing of the leaves.

7.4. Methods of storing parsley leaves

Storage in cold stores with a normal atmosphere

The optimal conditions for storing parsley are provided by refrigeration chambers in which the temperature can be maintained at the desired and uniform level. Packages with parsley should be arranged in the chamber to ensure good air circulation. Free access of cold air to all packages with parsley prevents heating and steaming of the material. By maintaining optimal conditions in the refrigeration chamber (0°C and 98-100 % humidity), leaf parsley can be stored for up to 6-8 weeks. At a temperature of 18-20°C and humidity of 85-90 %, parsley retains its commercial viability for only up to 3 days.

Refrigerated storage with controlled atmosphere

The storage period of leaf parsley can be extended by 1-2 weeks using a controlled atmosphere in the refrigeration chamber. Reducing the oxygen content to 5-10 % and increasing carbon dioxide to 5-10 % contributes to further reducing the intensity of respiration and delaying the yellowing and ageing of the leaves.

VIII. HEALTH AND HYGIENE RULES

Dr Maria Grzegorzewska

During the harvest and preparation for sale of agricultural produce as part of an integrated plant production system, the producer shall ensure compliance with the following hygiene and health rules.

8.1. Personal hygiene of employees

1) Persons working in the harvesting and preparation of crop for sale should:
    a. not be a carrier of, or suffer from, diseases that can spread through food;
    b. have an appropriate health booklet;
    c. maintain personal cleanliness, obey the rules of hygiene, and in particular often wash hands during work;
    d. wear clean clothing and, where necessary, protective clothing;
    e. treat injuries and abrasions with a waterproof dressing.
    f. have long hair tied or pinned up and, in justified cases, wear headgear completely covering the hair.
2) The plant producer must ensures that the workers that participate in the harvesting and preparation of the crop for sale have:
    a. unlimited access to washbasins and toilets, cleaning products, paper towels or hand dryers, etc.;
    b. training in hygiene.

8.2. Hygiene requirements for crops prepared for sale

The crop producer should take appropriate measures to ensure:
    a. clean or consumption-class water is used to wash the crops as necessary;
    b. the protection of crops during and after harvest against physical, chemical, and biological contamination.

8.3. Hygiene requirements in the integrated system of crop production for packaging and means of transport and places for preparing crops for sale

A producer in an Integrated Crop Production system shall take appropriate measures to ensure that:
    a. the rooms (including equipment), means of transport and packaging are kept clean;
    b. farmed and domestic animals have no access to the rooms, vehicles and packaging;
    c. order is maintained on driveways and around buildings where merchandise is stored and prepared for trade;

d. harmful organisms (plant pests of plants and organisms that are dangerous to people) that may be the cause of contamination or human health hazards, e.g. mycotoxins, are eliminated;
e. hazardous waste and substances are not stored together with crops prepared for sale.

IX. GENERAL RULES GOVERNING THE ISSUE OF IP CERTIFICATES

The intention to apply integrated plant production shall be notified by the plant producer every year to the certifying authority within the period set out in Article 55(2) of the Plant Protection Products Act of 8 March, 2013. The integrated plant production system is open to all producers. Notification of the intention to participate in the system is possible in paper form by post, in electronic form, and directly.

Training in integrated plant production is widely available, and individuals who have acquired the relevant knowledge in course of their education (as confirmed by a secondary school or a university) are exempted from the obligation to complete the basic training.

The certification body inspects growers who follow the principles of integrated plant production. Supervisory actions cover in particular:

- confirmation of completion of training in integrated plant production,
- production in accordance with the methodologies approved by the Main Inspector of Plant Health and Seed Inspection;
- methods and regularity of documentation;
- sampling and control of maximum residue limits for plant protection products and levels of nitrates, nitrites and heavy metals in plants and plant products;
- following hygiene and health principles.

The maximum permissible plant protection product residue content and nitrate, nitrite and heavy metal levels in plants are tested in the plants or plant products of no less than 20% of the plant producers listed in the plant producer register held by the certification body, starting with any plant producers suspected of not following integrated plant production principles.

The tests are carried out in laboratories accredited to the relevant extent pursuant to the provisions of the Act on the Conformity Assessment System of 30 August 2002 or the provisions of Regulation No 765/2008.

Producers of plant products intended for human consumption should know the values of the maximum permissible pesticide residue level (Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin). They should seek to reduce and minimise residues by extending the period between the use of pesticides and harvest.

The currently binding values of maximum permissible residue levels of pesticides in the European Community are published at:https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/mrls.

The certificate issued at the request of the plant producer certifies the application of Integrated Plant Production.

The certificate which certifies application of Integrated Plant Production is issued if the crop producer meets the following requirements:

- has completed training in integrated plant production and holds a certificate of completion of that training, subject to Article 64(4), (5), (7), and (8) of the Plant Protection Products Act,
- conducts production and protection of plants according to detailed methodologies approved by the Main Inspector and made available on the website of the Main Inspectorate of Plant Health and Seed Inspection,
- applies fertilisation based on the actual demand of plants for nutrients, determined in particular on the basis of soil or plant analyses,
- plant protection requirements relating to harmful organisms, in particular those specified in the methodologies have been complied with,
- documents the correct implementation of activities related to integrated plant production in the IP notebook,
- complies with hygiene and sanitary rules concerning the production of plants, in particular, those specified in the methodologies;
- in plant and plant product samples collected for testing, no maximum permissible residues of plant protection products and levels of nitrates, nitrites, and heavy metals have been exceeded.

Integrated plant protection certificates are issued for the period necessary for the product to be disposed of, but no longer than 12 months. Growers who have been granted a certificate attesting that they follow integrated plant production principles may use the Integrated Plant Production mark to distinguish the plants for which the certificate has been issued. The sample mark is provided by the Chief Inspector at the website of the Chief Inspectorate of Plant Health and Seed Inspection.

X. RULES FOR DOCUMENTATION IN INTEGRATED PLANT PRODUCTION

Dr Grzegorz Gorzała

Cultivation of plants in the integrated plant production system is inherently linked to the maintenance or possession of various types of documentation by the agricultural producer. An obligatory item of this documentation is the IP notebook.

A model notebook is included in the annex to the Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on documenting activities related to integrated plant production (i.e. Journal of Laws of 2023, item 2501).

Other documents that a producer using integrated plant production must or may have during the certification process include:

- the methodology of integrated plant production;
- the notification of accession to integrated plant production;
- the certificate of the registration number;
- programme or conditions for certification of integrated plant production;
- the price list for the certification of integrated plant production;
- the contract between the agricultural producer and the certification body;
- rules for dealing with appeals and complaints;
- information on GDPR;
- lists of plant protection products for IP;
- inspection reports;
- mandatory and control lists;
- test results on residues of plant protection products and levels of nitrates, nitrites and heavy metals in agricultural crops;
- soil and leaf test results;
- certificates of completion of training;
- reports or proof of purchase attesting to the technical functioning of the equipment for applying plant protection products;
- purchase invoices for, among others, plant protection products and fertilisers;
- application for a certificate;
- IP certification.

The certification process begins with the completion and submission, within the statutory deadline, of the application for integrated plant production by the producer to the certification body. A model application may be obtained from the certification body or downloaded from its website.

The application form should be completed with information such as:

- the name, address and place of residence or the name, address and registered office of the plant producer;
- the PESEL (personal identification) number, if one has been assigned to them.

The application must also include the date and signature of the applicant. The declaration shall be accompanied by information on the species and varieties of plants to be grown under the IP system and the location and area of their cultivation.

A copy of the certificate of completion of training in integrated plant production or a copy of the certificate or copies of other documents proving the qualification must also be attached to the application.

During cultivation, the agricultural producer is obliged to keep records of activities related to integrated plant production in the IP notebook on an ongoing basis. When applying for certification for more than one plant species, IP notebooks must be kept individually for each crop.

The Notebook should be filled in according to the following outline.

Cover — the plant species and the year of cultivation as well as the number in the plant producers' register should be stated on the cover. Then, own information must be added.

Inventory of fields (...) in the integrated plant production system — all cultivated varieties declared for IP certification to be recorded in the field inventory table.

Field plan with biodiversity-increasing elements — graphically reproduce the plan of the farm and its immediate surroundings with the proportions of the various elements. The farm plan uses the same markings as those used in the list of fields.

General information, sprayers, operators — the year in which production according to the principles of Integrated Plant Production was started is to be recorded. Then, tables must be filled in. The bullet points should be filled in with appropriate entries and the information confirmed by ticking the relevant boxes (□). The 'Sprayers' table should be filled in with the required data and the information confirmed by ticking the relevant boxes (□). Note all sprayers operators carrying out plant protection treatments in the 'Sprayer operator(s)' table. It is absolutely necessary to indicate that the training in the use of plant protection products is up to date, including the date of completion (or other qualification). In the 'Sprayers' and 'Sprayer operator(s)' tables, all devices and persons performing treatments, including those performed by a service provider, are listed.

Purchased plant protection products — the purchased plant protection products (trade name and quantity) intended to protect the crop for which the Notebook is kept should be recorded in the table.

Monitoring tools, e.g. colour sticky boards, pheromone traps — in the table, record the used colour sticky boards, pheromone traps, etc. and indicate pests which these tools were intended to monitor.

Crop rotation — the crop rotation table should be filled in with the crop and the code of the field on which it was cultivated. Crop rotations must be reported for the period (number of years) specified in the methodology.

Seed material (...) - complete the table by entering information about the purchased seed, including species, variety, category, degree of qualification, quantity, and proof of purchase (invoice), label or plant passport, marketing label, supplier's document.

Sowing (...) — in the table, record the quantity of seed used in individual fields. The dates of the activities carried out should also be recorded. For this purpose, tick the relevant boxes (□) to confirm the information on soil testing/assessment for existing pests which would exclude the field from IP cultivation.

Soil/substrate and plant analysis and fertilisation/fertigation — soil analysis is a fundamental activity to determine the fertiliser needs of plants. The IP producer must carry out such analyses and record them in the notebook. In the table 'Soil and plant analysis'

enter the field code, the type or scope of the tests and the number and date of the report. All organic fertilisers applied should be recorded in the 'Organic fertilisation (...)' table. If organic material was used, the species or specie composition should be indicated in the 'Fertiliser type' column. The date, type and dose of fertilisation and liming applied and the field should be recorded in the 'Soil mineral fertilisation and liming' table. The 'Observations of physiological disorders and foliar fertilisation' table should be used to record observations regarding plant nutritional deficiencies and fertilisers applied. The IP grower must regularly inspect the crops for the occurrence of physiological diseases and record this fact each time. Foliar fertilisation should be correlated with the observations of physiological disorders carried out.

Control observations and record of plant protection treatments — the plant protection tables are the basic element of the IP Notebook. The first table 'Observations of weather conditions and plant health' is a detailed record of observations, in which we record the data indicated in the heading. In this table, the need for chemical treatment is also indicated. The next two tables are registers of plant protection treatments (agrotechnical, biological and chemical) and are closely correlated with the observation table. When carrying out this type of procedure, it is mandatory to record the name of the plant protection product or the biological or agrotechnical method applied, as well as the date and place of treatment. Table 'Other chemical treatments applied (...)' is a record of all treatments authorised for use on the crop that are not listed in the previous tables e.g. the use of desiccants. **Filling the mandatory IP notepad in the integrated plant production system fulfils the requirement to keep the above-mentioned documentation for certified crops.** The rules for documenting plant protection treatments will change on 1 January 2026 as a result of the application of the provisions of Implementing Regulation (EU) 2023/564.

Harvest — in this table, record the volume of crop taken from each field.

Hygiene and sanitation requirements — record whether people in direct contact with food have access to clean toilets and hand-washing facilities, cleaning products, and paper towels or hand dryers. Also the manner of observing the hygiene and health requirements for IP methodologies should be described.

Other mandatory requirements for the protection of plants against pests according to the requirements of the integrated production methodology — a page in the notebook containing space for IP producer's comment concerning requirements for plant protection against pests set out in the integrated plant production methodologies.

Information relating to cleaning of machines, equipment, and hardware used in production according to the requirements of the integrated production methodology — a page in the notebook containing space for IP manufacturer's for information relating to cleaning of machinery, equipment, and hardware used in manufacturing which is required in the integrated production methodology.

The Notebook also has a space for comments and own notes and a list of appendices.

It is possible for an agricultural producer to obtain an IP certificate by applying to a certification body. Forms for the relevant applications are available from the certification

bodies. Along with the completed application for a certificate certifying the use of integrated plant production, the plant producer shall provide the certifying operator with a statement that the crop was carried out in accordance with the requirements of integrated plant production and information on the species and varieties of plants grown using the requirements of integrated plant production, the area of their cultivation and the yield size.

XI. CONTROL LISTS FOR INTEGRATED PRODUCTION

LIST OF OBLIGATORY ACTIVITIES AND TREATMENTS IN THE INTEGRATED PRODUCTION SYSTEM FOR ROOT AND LEAF PARSLEY

Mandatory requirements (100% compliance, i.e. 16 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Crop rotation – not cultivating root and leaf parsley after other plants of the Apiaceae family, as well as after other root vegetables, in the same field, more frequently than every 4 years (see chapter II, 2.2; chapter V, 5.1).	❑/❑	
2.	Determination of the soil reaction in the year preceding the cultivation of parsley, confirmed by the results of the analysis and liming, if necessary. Cultivation is also permitted if the determination of the soil reaction is carried out in the year of the beginning of the crop, provided that the soil pH is within the optimum range for the crop (see chapter II, 2.3).	❑/❑	
3.	Analysis of soil abundance before the start of parsley determination of fertilising needs (confirmed by the results of soil analysis) and application of optimal fertilisation (see chapter II, 2.3).	❑/❑	
4.	Vegetable seed sowing of at least standard category, storage of labels, plant passports, supplier's document and proof of purchase of seed (see chapter II, 2.7.).	❑/❑	
5.	Recognition of weed species in the field intended for the cultivation of root and leaf parsley in the year preceding their cultivation and entering their names in the Integrated Production notebook (see chapter IV, 4.1).	❑/❑	
6.	Mowing of uncultivated areas belonging to the same farm around the plantation (e.g. margins, ditches, roads), at least twice a year (end of May/beginning of June and end of July/beginning of August) in order to prevent the release of seeds by weeds (see chapter IV, 4.2).	❑/❑	
7.	Monitoring of plantations (at least once a week) for	❑/❑	

	the presence of the following diseases: alternaria leaf spot, powdery mildew (see chapter V, 5.1).		
8.	Prophylactic/interventional control of alternaria leaf spot and powdery mildew, only after a risk of infection has been identified, on the basis of an analysis of weather conditions and/or after the onset of the first signs of disease (see chapter V, 5.1).	❑/❑	
9.	Alternate use of plant protection products with different mechanisms of action to prevent agrophage resistance to pesticides (if possible) (see Chapter III, Chapter V, 5.1).	❑/❑	
10.	Performing soil analysis for the presence of nematodes in an accredited nematology laboratory (see chapter VI, 6.1.)	❑/❑	
11.	Monitoring the timing of the appearance of carrot flies using yellow sticky boards - at least 3 per plantation (see chapter VI, 6.1.).	❑/❑	
12.	Monitoring of plantations (at least once a week), for the presence of aphids (see chapter VI, 6.1.).	❑/❑	
13.	Monitoring the flight of cereal cutworm using pheromone traps (at least 2 units/ha) and inspecting them at least once a week, as well as monitoring for the occurrence of parsley damage caused by cutworm caterpillars and wireworms (see chapter VI, 6.1.).	❑/❑	
14.	Inclusion in the pest and pathogen protection programme of non-chemicals (at least one of the treatments performed should be made with such a preparation) (see chapter V. 5.1; chapter VI, 6.1.).	❑/❑	
15.	Creating suitable conditions for the presence of birds of prey by setting up at least 1 rest pole per 5 ha, and in the case of larger plantations — several poles (see chapter VI, 6.1.).	❑/❑	
16.	Placing shelters for mason bees or bumblebees in the number of at least 1 per 5 ha, and in the case of larger plantations – several shelters (see chapter VI, 6.5.).	❑/❑	
NB! Traps and sticky boards used for monitoring pest infestations on plantations must be placed facing the direction from which the pest is expected to fly in (tree cover)			

NB!
The carrying out of all the obligatory actions and treatments under integrated production must be documented in the Integrated Production Notebook.

CHECKLIST FOR FIELD VEGETABLE CROPS

Basic requirements (100% consistency, i.e. 29 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Does the producer follow the detailed methodology approved by the Main Inspector with regard to the production and protection of plants?	□/□	
2.	Does the producer have up-to-date IP training confirmed by a certificate, subject to Articles 64(4), (5), (7) and (8) of the Plant Protection Products Act?	□/□	
3.	Are all required documents (e.g. methodologies, notebooks) present and kept on the farm?	□/□	
4.	Is the IP Notebook kept correctly and up to date?	□/□	
5.	Does the producer apply fertilisation on the basis of the actual nutrient requirements of the crops, determined in particular on the basis of soil or crop analyses?	□/□	
6.	Does the producer perform winter ploughing in the autumn period?	□/□	
7.	Does the producer systematically monitor the crops and record them in a notebook?	□/□	
8.	Does the producer dispose of empty packaging of crop protection products and products that are out of date in accordance with the applicable legal regulations?	□/□	
9.	Is chemical protection of crops replaced by alternative methods wherever justified?	□/□	
10.	Is chemical plant protection carried out based on economic harm thresholds and the signalling of harmful organisms (wherever possible)?	□/□	
11.	Are treatments performed with the use of plant protection products carried out exclusively by persons who hold, for the duration of treatment, a valid certificate of completion of training in the use of plant protection products or advisory on plant protection products, or integrated crop production, or another document confirming certification to apply plant protection measures?	□/□	
12.	Are the applied plant protection products approved for use in the plant?	□/□	
13.	Is each use of plant protection products recorded in the IP Notebook, taking into account the reason for use, the date and place of use and the surface area of cultivation, the dose of the preparation and the amount of spray liquid per unit of surface	□/□	

Basic requirements (100% consistency, i.e. 29 points)			
	area?		
14.	Were the plant protection treatments carried out under appropriate conditions (optimal temperature, wind below 4 m/s)?	□/□	
15.	Is the rotation of the active substances of the crop protection products used for the treatments respected, if possible?	□/□	
16.	Does the producer limit the number of treatments and the amount of crop protection products used to a necessary minimum?	□/□	
17.	Does the producer have measuring devices to precisely determine the quantity of the measured plant protection agent?	□/□	
18.	Are the conditions for safe use of the agents respected, as set out on the labels?	□/□	
19.	Does the producer comply with the provisions of the label concerning the observance of precautions related to environmental protection, i.e. e.g. the observance of protective zones and safe distance from areas not used for agricultural purposes?	□/□	
20.	Are prevention and withdrawal periods observed?	□/□	
21.	Are the doses and maximum number of treatments per growing season specified on the label of the plant protection product not exceeded?	□/□	
22.	Are the sprayers referred to in the IP Notebook in good technical condition and are their technical inspection certificates up to date?	□/□	
23.	Does the producer carry out systematic calibration of the sprayer(s)?	□/□	
24.	Does the producer have a separate place for the filling and washing of sprayers?	□/□	
25.	Does the handling of usable residual liquid comply with the provisions indicated on the labels of plant protection products?	□/□	
26.	Are crop protection products stored in a marked closed room in such a way as to prevent contamination of the environment?	□/□	
27.	Are all plant protection products stored only in their original packaging?	□/□	
28.	Does the IP producer observe hygienic and sanitary principles, especially those specified in the methodologies?	□/□	
29.	Are appropriate conditions for the development	□/□	

Basic requirements (100% consistency, i.e. 29 points)			
	and protection of beneficial organisms ensured?		
	Total points		

Additional requirements for field vegetable crops (minimum compliance 50 %, i.e. 11 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Were the plant varieties grown selected for Integrated Plant Production?	□/□	
2.	Is each box marked according to the entry in the IP notebook?	□/□	
3.	Does the producer use the correct crop rotation?	□/□	
4.	Did the producer perform all the necessary agrotechnical procedures in accordance with IP methodologies?	□/□	
5.	Does the seed used (seeds, seedlings) meet the production and quality requirements?	□/□	
6.	Is the recommended catch crop used in cultivation?	□/□	
7.	Are steps taken on the holding to reduce soil erosion?	□/□	
8.	Are expired plant protection products stored separately in the plant protection products warehouse?	□/□	
9.	Are sprayers specified in the IP Notebook used for the treatment?	□/□	
10.	Are protective clothing and health and safety rules observed during care work, especially during spraying?	□/□	
11.	Are fertiliser application machines maintained in good working order?	□/□	
12.	Do fertiliser application machines allow for accurate dose determination?	□/□	
13.	Is each fertiliser applied recorded with regard to its form, type, date of application, quantity, location and surface?	□/□	
14.	Are fertilisers stored in a separate and specially designated room in a manner that ensures protection of the environment against contamination?	□/□	
15.	Does the producer protect empty PPP packaging against unauthorised access?	□/□	
16.	Is drinking class water used for washing vegetables?	□/□	

17.	Is the access of animals to storage, packaging and other processing areas for crops restricted?	□/□	
18.	Does the producer have a properly prepared place for collecting organic waste and sorted vegetables?	□/□	
19.	Are there first-aid kits near the workplace?	□/□	
20.	Are hazardous areas on the farm, e.g. plant protection product storage rooms, clearly marked?	□/□	
21.	Does the producer use consultancy services?	□/□	
	Total points		

Recommendations (implementation min. 20 %, i.e. 3 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Are soil maps drawn up for the farm?	□/□	
2.	Are inorganic fertilisers stored in a clean and dry room?	□/□	
3.	Has a chemical analysis of organic fertilisers been carried out in terms of nutrient content?	□/□	
4.	Is there an irrigation system on the farm that ensures optimal water consumption?	□/□	
5.	Is the irrigation water tested in a laboratory for microbiological and chemical contamination?	□/□	
6.	Does the lighting in the room where the plant protection products are stored make it possible to read the information on the packaging of the plant protection products?	□/□	
7.	Are there instructions on how to deal with spills or scattering of plant protection products on the farm, and are there tools to counteract such a threat?	□/□	
8.	Does the producer restrict access to the keys and the warehouse in which the plant protection products are stored, to persons who do not have the authority to use them?	□/□	
9.	Does the producer store on the farm only plant protection products allowed for use with the plant species they cultivate?	□/□	
10.	Is the water used to prepare the spray liquid of the correct quality, including the correct pH?	□/□	
11.	Are wetting agents or adjuvants added to the spray liquid to improve the effectiveness of treatments?	□/□	
12.	Does the producer improve their knowledge at Integrated Plant Production meetings, courses or	□/□	

	conferences?		
	Total points		

XIII. LITERATURE

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