MAIN INSPECTORATE OF PLANT HEALTH AND SEED INSPECTION

PIORIN

DRAFT

INTEGRATED PRODUCTION METHODOLOGY OF LEEK

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

by
the Main Inspector of Plant Health and Seed Inspection

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INTEGRATED PRODUCTION

OFFICIALLY CONTROLLED

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I. INTRODUCTION

Integrated Plant Production (IP) is a modern food quality system, involving the sustainable use of technical and biological advances in plant cultivation, protection and fertilisation with the purpose of protecting human health and the environment. The essential component of the system is the application of integrated plant protection principles, which have been mandatory for all professional users of plant protection products since 1 January 2014. In particular, these prioritise the use of non-chemical methods, which should be complemented by the use of pesticides.

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 (IPP) 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 (consolidated text: Journal of Laws of 2024, item 630), Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on documentation of activities related to integrated plant production (Journal of Laws of 2013, item 788) and Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on the qualifications of persons carrying out control activities on compliance with the requirements of integrated plant production and the model certificate certifying the use 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 plant protection products (Journal of Laws of 2022, item 824).

The Integrated Production methodology for leek covers all issues related to cultivation, fertilisation, site selection, crop rotation, soil preparation, sowing, irrigation, agrotechnical treatments, variety selection as well as protection against agrophages and harvesting and storage. The methodology also takes into account the hygienic and sanitary principles to be observed during harvesting and preparation for the sale of agricultural products produced in the integrated plant production system and general rules for issuing certificates in integrated plant production as well as a list of mandatory activities and treatments in the integrated production system for leek.

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. ORIGIN AND DESCRIPTION OF THE SPECIES

Agnieszka Długosz, Eng. Natalia Skubij, PhD Eng.

Leek comes from a perennial green plant – *Allium ampeloprasum holmense*, occurring from Portugal in the west to the eastern shores of the Mediterranean Sea, all the way to Iran. The history of its cultivation dates back to as far as ancient Egypt, Greece and Rome. It arrived in Central Europe in the Middle Ages, having probably been brought here by the Crusaders.

Leek (*Allium ampeloprasum* ssp. *porrum*) belongs to the Amaryllidaceae family, the Allioideae subfamily, and is a biennial plant, which in the first year of cultivation produces edible parts—bulbs and leaves, while in the second year, it produces flowering shoots. The main stem, which is strongly shortened, woody, and has short internodes, forms the so-called basal plate in the first year of cultivation. The leaves in the upper part are flat, lanceolate, while in the lower part they transition into fleshy leaf sheaths, overlapping each other, forming a pseudostem up to 5-6 cm thick and up to 40 cm long. The lower part of the leaf sheath is white, and the upper part is green. The leek bulb has a single apical meristem and, depending on the variety, takes the shape of: short rounded or cylindrical, medium long rounded or long cylindrical. From the lower part of the basal plate grows a fibrous and strongly developed root system. Most of the roots develop in the upper layer of the soil, with a few reaching a depth of 125 cm.

In the second year of cultivation, starting from the third decade of May, unleaved flowering shoots appear, reaching a height of 130 to 200 cm. White-green, pale pink or light purple, bisexual leek flowers are collected in headed umbels with a diameter of 6 to 10 cm. In one umbel there are from 200 to 1500 flowers, blooming during the long day (including from June 10 to July 20). The fruit of the leek is a capsule that contains up to 6 black, triangular seeds – smaller than those of onions and more wrinkled. In one gram, on average, there are from 350 to 400 seeds, the germination capacity of which is preserved for a period of 2-4 years. After sowing, they emerge after 2-3 weeks.

2.1. Nutritional value and economic significance

The nutritional value of leek is due to the high content of mineral salts, especially calcium and phosphorus, and vitamins. The average dry matter content is 12-13 %, of which 1.7 % is protein, 9.9 % is carbohydrates, and 0.3-0.4 % is fat. The energy value of 100 g of dry matter is 197 kJ. In contrast, the level of ash components reaches 0.8-1.5 g, of which calcium is 60 mg, phosphorus 30 mg, and iron 1 mg in 100 g of ash. In 100 g of fresh leek, there are over 91 g of water, 5.7 g of carbohydrates, 2.2 g of protein, 20 mg of vitamin C and 0.3 g of fats, which is 121 kJ (29 kcal).

In cultivation, leek is treated as an annual plant, intended for direct consumption and for the fresh market, for bunch harvesting, for the production of dried produce or as an ingredient in frozen vegetable mixtures. Its cultivation is widespread in Western European countries. According to data of the Polish Agency for Restructuring and Modernisation of Agriculture obtained on the basis of producers' declarations in direct payment applications, the area under cultivation in Poland in 2020-2024 was 1,470-1,715 ha.

2.2. Climate and soil requirements

Leek belongs to plants with relatively low climatic requirements. The optimum growth temperature is 15-20°C, and the maximum is 28°C. Seeds germinate at a temperature of 3-4°C, with emergence occurring only after 50 days. With temperature rising to 12°C, emergence occurs after 12-17 days, and for 18-20°C it's 8-10 days. Fully grown plants show considerable resistance to low temperatures. Early varieties withstand a temperature drop to -10°C, and late varieties to -15°C, which allows the plants to remain in the field during the winter months.

The light requirements for the season are high, so crops should not be located in shaded sites or in conjunction with plants that have strong growth. With a long day and in conditions of relatively low temperature, within 12-15°C, some plants can produce flowering shoots already in the first year of cultivation. This is especially true of early varieties.

Early leek varieties intended for very early harvesting should be grown on lighter, humus-rich soils that warm up and dry quickly in spring. Plants intended for later harvesting are best grown on medium-textured, fertile soils with high water retention and no crusting, which is important when growing leek from seed. Soils made of light clays, loess, as well as peat soils, are recommended for leek cultivation with the intention of harvesting in the autumn. Soils that are very light and very heavy are inadequate for growing leek.

The water needs of leek are high, defined as about 500 mm of rainfall during the growing season. Leek plants are particularly sensitive to water scarcity during the germination and emergence phase, just after planting the seedlings in a permanent location, and during the phase of intensive plant growth. In the final part of the growing season, excess water in the crop is inadvisable, as it increases the sensitivity of plants to frost.

III. AGROTECHNICS IN INTEGRATED LEEK PRODUCTION

A. Długosz, Eng. N. Skubij, PhD Eng.

3.1. Site and crop rotation

The best preceding crops for leek are plants that leave the field as early as possible, leaving it free of weeds. Plantations of this plant in crop rotation are best considered after peas, beans, beets, tomatoes, cabbages, cauliflowers, cucumbers or other cucurbits, as well as cereal plants. Crops of leek should not be planted after bulbous plants (onions, garlic, leek) or in fields with the possibility of infestation by the stem nematode (*Ditylenchus dipsaci*) or fields already infested by it. It is not recommended to plant leek crops on the

same field more often than every 4 years. For phytosanitary reasons, it is advisable to locate crops in open and airy spaces, away from water reservoirs, clusters of trees and shrubs, and land depressions.

Leek should not be grown after each other and other species of bulb vegetables of the Amaryllidaceae family due to the possibility of infection by the same pathogens and pests.
A 4-year crop rotation eliminates or significantly reduces the presence of pests threatening leek plantations.

3.2. Soil cultivation

In the cultivation of leek, careful and timely implementation of cultivation procedures plays a significant role, depending on the condition of the field, the date of sowing/planting, row spacing, and plant density. In cultivation from seedlings, after pre-crops have left the field early, shallow ploughing must be carried out as soon as possible. This treatment will reduce water losses from the soil and cover crop residues or cut straw enriched with mineral nitrogen, which can be an additional source of humus. Shallow ploughing is carried out with a subsoiler or a light plough to a depth of 6-8 cm with simultaneous harrowing. After incorprating the straw, as a catch crop, mixtures of leguminous plants for autumn ploughing can be incorporated. If, on the other hand, no catch crop is sown, then the field should be harrowed as weeds appear. After plants that are harvested late from the field, a cultivator is used. Manure applied in the autumn period should preferably be covered with medium ploughing 2-3 weeks before winter ploughing. If green fertilisers are used instead of manure, they should be cut early in autumn and disked to accelerate the decomposition of organic matter. Deep pre-winter ploughing to the full depth of the arable layer is the main tillage operation performed before the planned cultivation of leek. If, after plants leaving the field late, no shallow ploughing was performed or manure was applied for winter ploughing, it is advisable to use a plough with a skim coulter.

In the cultivation of leek from sowing, due to the relatively short time for sowing seeds, spring tillage should be started as early as possible, and it is best to use tillage units. The first to be used is a unit consisting of a harrow and a string roller, and after sowing fertilisers, the unit, which is a cultivator and a string roller. Pre-sowing treatments can also consist of a system of successive operations, carried out as needed with different tools, e.g. a drag, harrow, cultivator, with simultaneous mixing of fertilisers with the soil. Treatments should be carried out carefully, and the top layer of the soil well levelled and loosened in the surface layer. Such soil preparation not only facilitates the direct sowing of seeds into the ground, but also facilitates the planting of seedlings to the same depth. In integrated production, due to the reduction of organic carbon losses, the number of cultivation treatments should be minimised, but the soil should be well prepared for sowing.

3.3. Methods and time of cultivation

Leek can be grown from sowing directly into the ground or from seedlings prepared in a greenhouse or polytunnel. **A minimum standard category seedlings may only be used for sowing in the field or seedling production, and labels and proof of seed purchase must be kept and, if seedlings are purchased, supplier documents and plant passports must be retained.**

Direct sowing of seeds into the ground is a simpler and less labour-intensive leek cultivation system than planting seedlings on a permanent site. However, cultivation from sowing on heavy soils with a high tendency to crusting should not be assumed. The field for sowing should be carefully prepared, with an even surface, free from clumps, stones and weeds. Leek grown by this method produces an equally high yield, but with less uniform quality, resulting in a greater proportion of second-grade produce in the commercial yield. Plants of leek from sowing are characterised by a more strongly marked bulbous thickening and a shorter, whitened part of the pseudostem. On the other hand, cultivation from seedlings, although it requires more work, allows for easier weed control and enables obtaining a crop of better quality.

CULTIVATION BY SOWING

Leek seeds are sown as early as possible in spring, at the end of March or at the beginning of April, in carefully prepared, heated and moist soil, in rows spaced every 45 cm, to a depth of 1-2 cm. In large-scale cultivation, the spacing between the rows is usually 67.5 cm or 75 cm, depending on the wheelbase of the tractor. The standard for sowing with traditional seed drills is 2-3 kg/ha. However, with the use of precision seed drills, the quantity of seeds sown can be reduced to 0.8-1.0 kg/ha. The optimal density should be 18-22 pieces/m^2. Excessive plant density necessitates thinning. Before sowing, seeds should be treated to generally strengthen seedlings and protect plants from infestation by pathogens and pests (onion fly). This method of cultivation is used, among others, in late varieties of leek, for autumn harvest, for direct consumption and for processing, as well as for spring harvest, after wintering of plants.

CULTIVATION FROM SEEDLINGS

In the case of growing leek intended for early bunch harvest, seed sowing in sowing boxes is carried out in the greenhouse at the end of January or at the beginning of February, and in March the seedlings are transferred to a heated foil tunnel. The prepared seedlings are planted in mid-April at a spacing of 25x25 cm and covered for a period of 3-4 weeks, e.g. with white crop cover (winter).

For the summer (in the second half of summer) and autumn harvest, the seeds are sown in March in sowing boxes or in a frame or heated tunnel, in rows spaced at 10 cm. Approximately 20 g of seeds are used per 1 m^2. Approximately 200 seedlings are obtained from 1 gram of seeds. 170,000 to 200,000 seedlings are needed to plant an area of 1 ha of field. To obtain such a quantity of seedlings, 1.2-1.5 kg of seeds should be sown. During the

production of seedlings, it is necessary to ensure proper hydration of the emerging seedlings and subsequent watering of the young plants, and to maintain an appropriate temperature – after sowing the seeds at 20°C – after the emergence of the plants at approx. 16-18°C, and from the upright cotyledon phase to 12-15°C (a strong and stocky seedling is then obtained). A week before the planned planting, the seedlings should be hardened. The seedlings grown in the sowing boxes are placed outside the greenhouse, the frames are left uncovered, and the foil tunnels are intensively ventilated. At the same time, watering is limited. The production of seedlings usually takes 8 weeks; however, in order to obtain a more mature seedling for planting, this period may be extended to 12 weeks. Hardened, healthy, and watered seedlings can be planted permanently in the second half of May and June, depending on the planned harvest and use.

In cultivation, for the late-autumn harvest and spring harvest, after wintering, seedlings should be planted permanently from June to early July. For planting, seedlings of 12-14 weeks, or even 16 weeks, are used. In order to obtain such a well-grown seedling, the seeds are sown into an unheated frame or on a seedbed covered with a low foil tunnel, in the period from the beginning to mid-April.

Seedlings can be planted flat, on ridges, in furrows, or in holes. Cultivation of leek on flat ground is the most common, while on ridges it is used for very early cultivation for bunch harvesting. The remaining two methods of cultivation are used to obtain a long section of the bleached pseudostem. The leek seedling is then planted in furrows 15 cm deep, and the plants are earthed up twice during the growing season. When planting seedlings in holes with a depth of 20 cm and a diameter of 2-3 cm without pressing them with soil, the success of the crop depends largely on the loosening and moisture of the soil. In addition, the seedling intended for planting in holes or furrows should be sufficiently advanced in growth and have a thickness of approximately 6 mm. Preparation of seedlings for this type of crop takes 10-12 weeks, and it is necessary to sow 3-5 g of seeds per 1 m^2.

The leek seedlings in all cultivation methods can be planted individually or in groups of 2-3 in one place. Increased plant density (2-3 plants) is more recommended when the purpose of cultivation is harvesting for bunches or drying needs, where even less well-grown plants are a valuable raw material. The distance between the rows in the seedling cultivation is the same as in the sowing cultivation (every 45 cm). However, row spacing should be used depending on the purpose: for the summer harvest every 7-10 cm, for the autumn harvest every 12-15 cm, and for plants wintering in the field every 15-20 cm. The seedling planting depth is 6-8 cm.

In the cultivation of leek, the so-called transplanted seedlings can also be used, produced in boxes without pricking out, or seedlings planted in pots or multi-cell trays. **Seedling production should be carried out in peat substrates free of pathogens, and proof of purchase of the substrate must be confirmed**.

3.4. Selection of varieties

Grown leek varieties can be divided into two main groups, namely summer leek and winter leek. The summer seasons are characterised by a shorter growing period; they are cultivated for bunch harvesting and for supplying the market in the summer and autumn, as a raw material for direct consumption, for the production of dried vegetables, or as a component of frozen vegetable mixtures. They are not suitable for wintering in the field, as they have low frost resistance. The winter seasons, on the other hand, have a long growing season, lasting from 150 to 170 days, and thanks to their greater frost resistance, they winter well in the field under cover or uncovered.

Among the summer varieties, the following stand out: early, medium early, and medium late. Early and medium-early summer varieties are characterised by a faster growth rate, a light green colour of the leaves and a more delicate taste. On the other hand, varieties classified as medium-late are characterised by an upright habit of dark, blue-green leaves, a long and thick pseudostem, without tolerance for the formation of bulbous swellings. Winter varieties produce distinctly thickened bulbs and shorter pseudostems, and are characterised by dark green leaves covered with a layer of wax coating. After wintering, they are characterised by a rapid increase in mass.

The different varieties of leek will differ in earliness, the shape of the plants, the colour of the leaves, the length of the pseudostem, the size and shape of the bulbous swelling, the length of the bleached part, and their suitability for processing, storage, or taste.

The necessary information on leek varieties that can be grown in the IP system is provided on the website of the Centre for the Study of Varieties of Cultivated Plants (COBORU) under the tab ‘Selection of varieties for integrated plant production’ (https://www.coboru.gov.pl/pdo/ipr).

3.5. Fertilisation

On good sites, fertile soils, leek is usually grown in the second year, and even in the third year after manure, using mineral fertilisation in accordance with plant demand. However, on weaker soils with less humus and a small sorption complex, autumn manure fertilisation at a dose of 30 t/ha is recommended. 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 % 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 leek (especially early varieties), it is more advantageous to apply manure in autumn, ensuring it is incorporated immediately after application.

Manure fertilisation can be replaced by using other organic fertilisers, either own (compost) or purchased. Growing catch crops for incorporating is advisable. The recommended dose of these fertilisers depends on the nitrogen content and must not

exceed 170 kg N/ha. On the other hand, as catch crops (so-called green fertilisers), mixtures of leguminous plants enriching the soil with nitrogen and organic matter, or species with phytosanitary properties, e.g. phacelia, can be cultivated. For early and medium-early leek varieties, in the year preceding their cultivation (preferably until 1 August), sow a mixture for a summer catch crop, e.g. 60 kg vetch + 60 kg pea + 100 kg/ha field bean, or 100 kg narrow-leaved lupin + 120 kg pea + 6 kg/ha phacelia, which should be incorporated in late autumn. For late leek varieties, winter catch crops may be used, e.g. winter vetch in pure sowing (75 kg/ha) or a mixture of winter vetch with rye (60 kg vetch + 70 kg rye per ha). The use of winter green fertilisers is recommended primarily when it is possible to irrigate the field; otherwise, incorporating them in the spring can lead to drying of the soil. It is also important that plants grown for green manure are incorporated at least 4 weeks before sowing or planting seedlings, as incorporating them too late does not allow for sufficient decomposition of organic matter and makes it difficult to sow or plant leek seedlings.

Shredded cereal straw can also be used for growing leek as an organic fertiliser, which, when mixed with the soil, introduces a significant amount of organic matter, but is poor in nutrients, especially nitrogen. The ratio of carbon to nitrogen in straw is very wide and amounts to 80-100:1. Therefore, in order to counteract the negative impact of incorporated straw on the leek yield, it is recommended to use 8 kg of nitrogen per 1 tonne of straw, i.e. about 40 kg N per 1 ha in the form of mineral fertilisers, slurry, or liquid manure. This amount of nitrogen is needed by bacteria to decompose straw in the soil.

Leek is a vegetable with high nutritional requirements for nitrogen and average requirements for phosphorus and potassium. **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 can only be conducted after performing the soil chemical analysis. When determining the dose of fertilisers, attention should also be paid to the type of soil (heavy, light soils) and the exchange sorption of nutrients in the soil. The optimal mineral content in the soil should be (mg/dm^3): 70-120 N, 60-80 P, 175-200 K, 45-65 Mg, 1000-2000 Ca.

After analysing the soil and comparing it with the presented optimal contents, we 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 introduced into the soil from incorporated green fertilisers, manure, or compost. For this purpose, use should be made of the so-called fertiliser equivalents for the applied organic fertiliser as provided in the Code of Good Agricultural Practice.

Due to the short vegetation period of early and medium-early varieties and the limited nutrient uptake from poorly heated soil, the doses of phosphate fertilisers should be increased so that the abundance of this element reaches the upper threshold value. Therefore, when preparing the site for the cultivation of early leek, the soil should be fertilised with phosphorus and potassium during the autumn ploughing, carried out in the year preceding the cultivation. For medium-late and late leek varieties, these fertilisers can be spread under the cultivator two weeks before the planned planting of seedlings or sowing

of leek seeds. Potassium fertilisers should be used in the form of potassium sulfate. Leek belongs to plants sensitive to chlorine and therefore fertilisers in the form of chloride should not be used in the fertilisation of crops; if they must be used, it should be in the autumn. In contrast, nitrogen fertilisation in early varieties should be divided into two parts: Apply 2/3 of the nitrogen dose to the harrow/cultivator immediately before planting the seedlings, and the remaining 1/3 of the dose as a top dressing in the first decade of June. In the cultivation of late varieties of leek, nitrogen fertilisation should be divided into three parts: 2/4 dose of N should be applied pre-vegetatively – before sowing or planting seedlings, the remaining two portions should be top-dressed: 1/4 dose of nitrogen 3-5 weeks after planting seedlings and 1/4 dose approximately 8 to 10 weeks after planting (by mid-August at the latest). It is also possible to apply the entire dose of nitrogen before the growing season, provided that it is mixed with at least a 15 cm layer of soil. A 25 % higher dose of nitrogen is applied to heavier or irrigated soils. Irrigation causes leek plants to produce more above-ground mass and can lead to nitrogen leaching deep into the soil profile. However, the total nitrogen dose from all sources (requirements of the Nitrates Directive) must not exceed 250 kg N/ha.

The determination of mineral fertiliser doses depends on the nutrient content of the soil and should therefore be established on the basis of the results of the soil analysis prior to the start of leek cultivation. The pre-crop period for early and mid-early varieties of leek will refer to the autumn period for P, K, Mg, Ca content and the spring period for nitrogen content. However, for medium-late and late varieties, soil sampling and analysis of soil nutrient content (N, P, K, Mg, and Ca) should be carried out in spring. Soil analysis should be carried out at District Chemical and Agricultural Stations or other accredited laboratories. The most appropriate method for determining nutrient content in vegetable crops is the horticultural method (the so-called universal method according to Nowosielski with possible subsequent modifications), which informs about easily accessible mineral content for plants. Results of the content of components determined by this method are given in mg/dm^3 or in mg/l of soil.

In cultivation, the soil pH plays a significant role. The optimum pH of mineral soils is 6.4 to 7.0. 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 acidity of the soil. 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 magnesium-poor soils. 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 determining the soil pH and Ca content must be carried out in summer or autumn after the plants have left the field in the year preceding cultivation.

The cultivation of leek is also permitted if the determination of the soil reaction is carried out in the year of commencement of cultivation, provided that the soil pH is within the optimum range for the leek.

Soil fertilisation for leek cultivation should be carried out based on the results of soil analysis, in accordance with the recommended levels of N P K Mg Ca.

3.6. Irrigation

Leek plantations should be irrigated during periods of water deficit in the soil, especially during periods of peak water demand – at the stages of seed germination, emergence, seedling development, and plant growth. Due to the fact that leek is grown both from sowing and from seedlings and have different harvest dates, there are different periods when there is a need to irrigate the plantation.

In cultivation from sowing, leek is sown early, so in the initial period, due to the slow growth and the possibility of using winter stocks, it does not require irrigation. The exception is the occurrence of prolonged drought during this period.

Leek grown from seedlings for summer, autumn, and early spring harvests should be watered immediately after the seedlings are planted in the field. The optimal period for irrigating leek intended for the summer harvest is from June until the harvest, for the autumn harvest from July to mid-September, and for the early spring harvest from mid-August to the end of September. Plants intended for wintering should not be irrigated at a later stage due to a decrease in frost resistance.

During a period of increased water demand, soil moisture should not fall below 70-75 % of the field water capacity of the soil. Seasonal water demand for leek cultivation in Polish climatic conditions ranges from 150 to 200 mm, while a single irrigation dose should be approximately 20-30 mm.

3.7. Care treatments

In the cultivation of leek, the basic care procedures include, among others, soil loosening. The treatment of loosening the soil between the rows is carried out with the help of tractor tools (weed harrow or light harrow) to a depth of 2-3 cm, so as not to damage the root system. The treatment is performed if soil herbicides are not used.

In sowing, when the seedlings are too dense, thinning is applied during true leaf phases 1-2 and with good soil moisture, ensuring that the seedlings do not break when being pulled out. The density of plants after thinning should not exceed 22 pcs./m^2.

In order to obtain a large part of the bleached pseudostem when growing leek planted in furrows, and sometimes also on a flat surface, plants are covered with soil up to a height of 15 cm. This procedure is performed in August and September. It is labour-intensive, which is why it is primarily used in the cultivation of plants intended for wintering in the field. When covered with soil, the plants are less damaged by frost.

3.8. Physiological disorders

Negative changes in the appearance of plants are not always the result of the occurrence of fungal, bacterial, and viral diseases or the action of pests. Disease symptoms on plants can be the result of physiological disorders (non-infectious diseases) caused by abiotic factors. Worrying changes in plants can be caused by water deficit or excess, low or high temperature, too intense light or lack thereof, abnormal soil reaction, nutrient deficiency or excess, and improper nutrient uptake. Among the symptoms of non-infectious diseases occurring in plants, the most commonly observed are weakened growth and dwarfism of plants, wilting, changes in leaf colouration, and their deformations.

In leek cultivation, possible physiological disorders include:

- **flaccid, withered seedlings** due to water scarcity or excess (disruption of air-water relations) or due to molybdenum deficiency;
- **inhibition of growth, chlorosis of leaves** have different causes, e.g. sulphur deficiency;
- **dwarfing of plants (bushy growth), narrow and short leaves** as a result of zinc deficiency;
- **bright colouring and twisting of leaves** triggered by manganese deficiency;
- **withering of leaf edges** caused by calcium and potassium deficiency on light soils, following precipitation and as a result of weather changes, i.e. sudden temperature spikes, light intensity, or drought;
- **drying from the top, pale green oldest leaves** due to phosphorus deficiency;
- **deformities of bulbs** resulting from mechanical damage to the basal plate and/or fluctuations in temperature and humidity;
- **spindleness of bulbs** in the form of a thick, juicy, undried neck as a consequence of prolonged planting of seedlings, delayed ripening of plants, rapid growth of bulbs, over-fertilisation with nitrogen and/or manganese, or potassium deficiency;
- **growth of leaves and roots during the storage period** due to improper plant nutrition – excessive nitrogen doses, high temperature and humidity before harvesting preceded by a period of drought, as well as inadequate storage conditions.

To eliminate or reduce the symptoms of physiological disorders in leek plants, the following should be performed **before planting:**

- perform a soil analysis and, on the basis of the results obtained, establish a fertilisation plan and regulate the soil pH to allow for efficient nutrient uptake by plants;
- apply proper fertilisation, according to the nutritional requirements of leek;
- apply humic acids (soil improvers), which prepare the soil for sowing/planting by improving its structure and air-water relations and activating organic components from organic matter, restoring biological activity and soil fertility, having a positive impact on increasing the quantitative and qualitative parameters of the yields obtained.

During cultivation:

- plant seedlings in carefully prepared soil, respecting the dates and rules of planting;

- monitor the crop for worrying symptoms and react promptly (by performing plant analysis, using growth promoters);
- after the occurrence of symptoms indicating a deficiency of a specific nutrient, apply supplementary fertilisation with fertilisers containing the mineral component;
- use growth promoters that stimulate the metabolism and life processes of plants, positively affect their growth and development, increase the resistance of plants to stress, e.g. planting, and support plant regeneration;
- during water scarcity, irrigate the plants, taking into account morning or evening hours;
- weeding treatments should be carried out carefully to prevent mechanical damage, especially during the formation of bulbs, which results in their deformation.

In addition, it is necessary to consider the selection of suitable varieties, adapting their characteristics to the cultivation period, thereby taking into account the harvest date and their suitability for consumption, processing, and storage.

IV. PROTECTION OF LEEK FROM HARMFUL ORGANISMS

Harmful organisms, i.e. pests (pathogens, weeds), are commonly found in vegetable crops; therefore, protection against them is an important element of the integrated production of these plants. Without effective regulation of the level of threat from pests, it is difficult to obtain a high yield of, good quality, while maintaining the profitability of production. In integrated crop production, the aim should be to reduce as much as possible the potential threat of pests by using mainly agrotechnical, biological, mechanical, if necessary, also chemical methods.

Prevention plays a very important role in counteracting the occurrence of all harmful organisms. The creation of optimal growth conditions for crop plants through proper shaping, careful cultivation, fertilisation and irrigation is of great importance in eliminating the negative effects caused by pests. Mechanical soil cultivation plays a significant role in the control of certain pests as well as destroys sprouting and emerging weeds and reduces the number of viable weed seeds. All growing operations prior to sowing seeds or planting seedlings should be carried out carefully, taking into account the current state of the site and in a timely manner. The correct sowing and planting dates, the appropriate row spacing and plant density should be chosen so that the use of chemicals can be kept to a minimum.

Chemical protection against pests should be carried out in accordance with the principles of integrated pest management, as stipulated, among others, by the relevant European Union directives (e.g. Directive 2009/128/EC) and the Plant Protection Products Act of 8 March 2013 (i.e. Journal of Laws of 2024, item 630) 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 regarding the quality of the products, their toxicology and their effects on arable crops and the environment ensure

that the recommended products do not pose a threat to the natural environment, the user and the consumer, provided that they are properly applied.

Integrated pest protection must respect the following principles:

♦ The need to perform the treatment with a plant protection product should be determined on the basis of the identification of pests and their intensity, harmfulness thresholds of economic harmfulness (TEH) or harmfulness threshold, as well as warnings on the appearance of pests, diseases, and forecast occurrence of weeds. It should be borne in mind that **thresholds of economic harmfulness are developed for specific, usually average growing conditions and cannot be uncritically adopted for specific plantations.** When performing a treatment when the pest population corresponds to the threshold of economic harmfulness, there is a risk that its population will continue to increase for various reasons, and then the losses in the value of the crop may exceed the cost of performing the treatment. In order to prevent such a situation, the treatment should be performed before the pest population reaches the threshold of economic harmfulness. Such a pest size is called a harmfulness threshold and is often referred to as 80 % of the TEH value.

♦ Leek disease control should be carried out once the risk of infection has been established on the basis of an analysis of weather conditions and/or after the first symptoms of disease have appeared.

♦ It is required to use products authorised for use in an integrated plant production system, in particular those with a short withdrawal period, that are short-lived in the soil, decompose rapidly, and have the least negative impact on the crop, the soil, and beneficial organisms.

♦ Always use the products authorised for use in the crop and intended to control the specified pest, and 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.

♦ 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 optimal for their effectiveness and in a manner that utilises their biological activity as much as possible, while minimising doses and consumption.

♦ **Non-chemical pathogens should be included in the programme for the protection against pests and pathogens (pathogens) of plants (at least one of the treatments should be performed with such a preparation).** These are preparations based on bacteria, fungi or viruses and plant extracts and means of natural origin.

♦ 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.

♦ If possible, use field mapping with modern methods (aerial or drone photos) to determine signs of damage, e.g. by pests or diseases, and weed distribution on the plantation, 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 when planning succession crops, grown both after the full cultivation time and in the case of early clearing of plantations due to winter damage, destruction of plants by disease or pests, etc.

♦ **Products with different mechanisms of action should be used (if possible) to prevent harmful organisms from becoming resistant to the active substances contained therein**. The alternating application of the products also results from the need to preserve biodiversity and protect the environment.

♦ The fungicides approved for IP should be used preventively or at the onset of the first symptoms.

♦ The effects of plant protection products on harmful organisms and arable crops depend on crop species and their developmental stages, pests, soil, and climatic conditions. Herbicides should be used only in phases of the highest sensitivity of weeds and in doses carefully adjusted to the soil conditions. Better efficiency and more economical consumption of some products can be obtained by adding adjuvants to the liquid.

♦ Herbicides generally work more strongly the higher the temperature, while some insecticides may act adversely or cause damage to the sprayed plants. It is recommended to spray plantations during rainless and windless weather, when the air temperature is 10-20°, if no other air temperature range is indicated on the label of the plant protection product. If the temperature is higher, treatments must be carried out in the early morning (when the plants 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 also 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 prior to the treatment. In the event of a break in spraying, before proceeding with application, the spray liquid should be mixed well with a stirrer.

♦ Residues of the spray liquid after treatment should be diluted with water and used on the treated area or disposed of using technical solutions ensuring biological degradation of the active substances of the plant protection products (e.g. biobed).

♦ After the procedure, the sprayer should be thoroughly washed, preferably using special agents intended for this purpose.

♦ 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 provincial inspector of plant health and seed inspection. During the preparation of agents and during treatments, the health and safety regulations must be followed, using appropriate protective clothing.

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.

The list of plant protection products authorised in Poland is published in the register of plant protection products available on the website of the Ministry of Agriculture and Rural Development at the following address: https://www.gov.pl/web/rolnictwo/rejestr-rodkow-ochrony-roslin. Information on the extent of use of pesticides in individual crops is provided in the labels of the products, on the website of the Ministry of Agriculture and Rural Development (https://www.gov.pl/web/rolnictwo/etykiety-srodkow-ochrony-roslin) A tool to assist in the selection of agents is a search engine for crop protection products (https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie).

The list of plant protection products for integrated production is developed by the Institute of Horticulture — National Research Institute in Skierniewice. The list of products authorised for integrated production is available on the website of the Institute of Horticulture – NRI: https://www.inhort.pl/rosliny-warzywne-wykaz-srodkow/ and in Vegetable Plant Protection Programmes, including leek, at https://www.inhort.pl/serwis-ochrony-roslin/ochrona-roslin-rosliny-warzywne/rosliny-warzywne-programy-ochrony/.

In addition, information on plant protection products for integrated production is published on the Pest Warning Platform on the website of the Institute of Plant Protection – National Research Institute in Poznań, at https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.

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 — The Institute of Plant Protection – National Research Institute in Poznań,

www.piorin.gov.pl – The National 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.

V. WEEDS

Dr Zbigniew Anyszka, dr Joanna Golian

5.1. Occurrence and harmfulness of weeds in leek cultivation

Leek is one of the species susceptible to weed infestation. It is characterised by a long growing season, which is why most of this period is exposed to strong competition from weeds. The level of sensitivity to weed infestation depends to a large extent on the method of cultivation and the date of sowing/planting. The presence of weeds in the cultivation of leek from sowing can cause yield losses of more than 80 %, and in cultivation from seedlings up to 60 %.

Leek grown from sowing emerges slowly and quite unevenly, especially during drought or periodic water shortages. Under unfavourable conditions, the germination period can extend to more than three weeks. Regardless of soil moisture, weeds appear even before the emergence of the crop, as well as during its emergence, which is why weed control treatments performed before the crop emerges are important in reducing weeds. After emergence, the leek grows very slowly, and due to its upright habit and narrow leaf blades, it poorly shades the soil, especially in the initial period of vegetation, which promotes the development of weeds. The strongest impact on the development of leek is exerted by weeds occurring from the emergence of the crop to the 3-5 leaf stage, in the so-called 'period of critical weed competition'. During this time, it is necessary to provide plants with a weed-free field. The presence of weeds at a later stage is not as dangerous, but it adversely affects the quality of the leek, delays its ripening, and may reduce the effectiveness of the plant protection products used. In addition, weeds strongly shade the leek plants and significantly weaken their growth by producing a large mass, making better use of water and nutrients taken from the soil.

Leek from seedlings can be planted in May for the summer-autumn harvest or in May-June for the autumn harvest and storage. Leek grown from seedlings is less sensitive to weed competition compared to cultivation from sowing; it grows for a shorter period in the presence of weeds, making it easier to remove weeds during the growing season, and the losses caused by weeds are smaller. Weeds occurring in small quantities within 2 weeks of planting do not have a large impact on the yield of the crop. It is assumed that the critical period of weed competition in the cultivation of leek from seedlings lasts from 3-4 to 7-8 weeks after planting. In cultivation, the period for autumn harvesting is extended to between 2 and 10 weeks from planting. The risk of weed infestation in leek, as in sowing crops, increases during drought.

The dynamics of the appearance of individual species of weeds over time depends on their biological properties, temperature and humidity, the date of sowing or planting, and the agrotechnics of the cultivated plant. Sources of weed infestation are seeds in the soil, transferred from neighbouring plantations and also from fields located at a considerable distance. Weed seeds may be dispersed: by wind (anemochory), water (hydrochory), animals (zoochory), spontaneously (autochory) or by humans (antropochory). In early spring, weed species germinating at low temperatures appear (daily average 1-5°C), such as: common lambsquarters, chickweed, mayweeds, knotweeds, shepherd's purse, field pennycress, wild mustard, common groundsel, small nettle, henbit dead-nettle, scentless mayweed, couch grass. At a higher temperature, the emergence of weeds such as small-flowered galinsoga, rough pigweed, barnyard grass, climbing knotweed, and black nightshade begins. These species may be present in both leek cultivation systems, with species with lower thermal requirements being more common during the sowing season. Many weed species have a very broad 'ecological optimum', i.e. they can appear at different times of the growing season, from spring to harvest, regardless of weather conditions. Those include white goosefoot, charlock, field pennycress, field pansy, pinweed and Persian speedwell. Secondary weeding is less dangerous than primary weeding, but the presence of weeds before harvesting promotes leek infestation by diseases, makes it difficult to use plant protection products, and hinders harvesting.

Table 1. Harmfulness of major weed species to leek crops (alphabetical list)

Species – English and Latin name	**Harmfulness**
1. Dicot weeds	
Common fumitory (*Fumaria officinalis* L.)	+
Field pansy (*Viola arvensis* Murr.)	+
Field mustard (*Sinapis arvensis* L.)	+++
Common chickweed (*Stellaria media* (L.) Vill.)	+++
Common stork's-bill (*Erodium cicutarium* (L.) L'Hér.)	+
Henbit dead-nettle (*Lamium amplexicaule* L.)	++
White goosefoot (*Chenopodium album* L.)	+++
False mayweed (*Matricaria maritima* L. subsp. *inodora* (L.), Dostál)	++
Annual nettle (*Urtica urens* L.)	++
Veronica (*Veronica* spp.)	+
Catchweed (*Galium aparine* L.)	+
Buck-bindweed (*Fallopia convolvulus* (L.) Á. Löve)	++
Field chamomile (*Anthemis arvensis* L.)	++
Groundsel (*Senecio vulgaris* L.)	+++
Red-root pigweed (*Amaranthus retroflexus* L.)	++
Shepherd's purse (*Capsella bursa-pastoris* (L.) Medik.)	+++
Field pennycress (*Thlaspi arvense* L.)	+++
Potato weed (*Galinsoga parviflora* Cav.)	+++

2. Monocot weeds	
Cockspur grass (*Echinochloa crus-galli* (L.) P. Beauv.)	+++
Common wild oat (*Avena fatua* L.)	++
Couch grass (*Agropyron repens* (L.) P. Beauv.)	++
Bristle grasses (*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 manufacturer to identify weed species present in the leek field and enter their names in the integrated production notebook**. Observations shall be conducted in the year preceding the cultivation of leek. For the proper identification of weed species, the Integrated Protection Methodology of leek which includes pictures of weeds in various developmental stages as well as available weed atlases, guides or special applications with numerous photos of weed species can be used. The methodology is available on the website of the Institute of Horticulture – National Research Institute in Skierniewice (https://www.inhort.pl/projekty-badawcze/projekty-finansowane-przez-mrirw/metodyki-naukowe/). In addition, weed species should also be identified during leek cultivation to facilitate protection in subsequent crops, and their names should be recorded in the IP notebook.

5.2. Non-chemical methods of weed control

In integrated production, weed control should be carried out using an integrated method in which non-chemical methods are preferred and herbicides complement them. Non-chemical methods include prophylaxis, agrotechnical methods including mechanical treatments and physical methods.

Prevention and agrotechnical methods

These include, among other things: selection of an appropriate plant for cultivation, appropriate crop rotation to prevent weed compensation, selection of varieties adapted to local soil and climate conditions, careful soil cultivation, fertilisation based on analyses of fertilising needs of arable crop and soil abundance, appropriate sowing and planting date and appropriate density of plants, careful care during cultivation, including irrigation during periods of water scarcity, preventing blooming and release of seeds by weeds.

NOTE! In order to prevent the release of seeds by weeds, as well as the transfer of weed seeds or their vegetative organs from neighbouring areas to leek plantation, it is **mandatory to mow uncultivated areas around the plantation which belong to the same farm** (e.g. field margins, ditches, roads), at least 2 times a year (end of May/beginning of June and end of July/beginning of August).

Mechanical methods of weed control

Mechanical treatments performed in the period preceding the sowing/planting of leek seedlings are used to create the appropriate soil structure, destroy weed seedlings, and reduce the content of their seeds in the soil. In crops where it is not possible to use herbicides (mainly organic), after sowing and before emergence, it is possible to destroy emerging weeds by harrowing the field. Such a treatment destroys small seedlings of broadleef weeds, but also part of the emerging leek plants. It does not destroy monocot weeds In practice, this method is rarely performed. Mechanical treatments performed during the cultivation of leek make it possible to keep weeds at a low level. The row spacing of leek should match the wheel track of the tractor and the spacing of tools that will be used for mechanical treatments. Currently, various tools are available to allow weeding between rows and within rows of plants. Manual and mechanical weeding during cultivation should be carried out after the appearance of weeds, preferably after rain or irrigation and after the soil has dried. In the cultivation of leek from sowing, the first mechanical weeding can be performed after emergence, in the 3-4 leaf stage of the leek, when rows of plants are clearly visible and after the appearance of weed seedlings (preferably from the cotyledon stage to 2-4 leaves). In seedling cultivation, the first weeding can be done after planting and the establishment of the leek seedlings, and after the appearance of weeds. Further mechanical or manual weeding can be carried out depending on the regrowth of weeds. The number of mechanical treatments, without the use of herbicides, depends on the dynamics of the appearance of weeds and weather conditions. In the cultivation of leek from sowing, there is usually a need to perform 4, and sometimes 5 mechanical treatments, and in the cultivation of leek from seedlings, 3-4. Mechanical procedures should be performed in a shallow manner at a uniform depth (usually 2-3 cm) when the weeds are small and grow roots less readily. When treatments are performed too deeply, they become more energy-intensive, can damage the root system of the leek and cause the displacement of germination-capable weed seeds into the upper layer of the soil.

After the application of herbicides, mechanical treatments or manual weeding should be carried out only if the weeds are not effectively destroyed. In this case, it is most often necessary to perform 1-2 mechanical treatments. The labour input in such a protection scheme is much smaller than in the case of cultivation without the application of herbicides.

Thermal weed control:

Weeds can also be controlled with flame (gas) weeders. This treatment can be carried out after the weeds have emerged across the entire field, before sowing or planting leek seedlings, or 2-3 days before the leek emerge in the anticipated rows of plants. It is also possible to burn weeds in inter-rows, during cultivation, preferably with burners equipped with shields to protect plants from high temperatures, but then a complementary manual weeding should be performed. Weeds treated with high temperature quickly die (within a few days); however, the effect of the treatment is short-lived and does not protect against the emergence of subsequent weeds. After the emergence of subsequent weeds, the treatment should be supplemented with the use of herbicides or mechanical weeding. It is

assumed that flame weeding delays the next weeding procedure by approximately two, sometimes up to three weeks. Weed burning is quite expensive and it is recommended mainly for organic crops. Mechanical procedures are more cost-effective.

5.3. Chemical protection against weeds

To prevent the occurrence of weeds, good agricultural practices should be observed during the entire crop rotation and weed control procedures ought to be performed. Perennial weeds present in the leek field can be destroyed in the summer-autumn period after the harvest of the preceding crop, using non-selective herbicides with systemic action. The use of these measures in autumn yields better results than in spring, and these measures can be applied until late autumn, provided temperatures are not too low. In the spring period, there is usually too little time to apply such measures, although it would be possible to use them with a delayed date for planting leek seedlings. Non-selective measures destroy annual monocot and dicot weeds and almost all species of perennial weeds, with the exception of field horsetail.

Herbicide selection rules

The use of herbicides cannot pose a risk to the health of humans and animals or to the environment. The choice of agents should depend on the existing weeds and their severity, as well as on weather conditions and soil moisture. In leek cultivation, the use of herbicides is necessary due to the long period of emergence, slow growth, and upright habit. However, chemical protection cannot be the only method of protection against weeds. For weeding the leek crop from sowing, it is recommended to use herbicides before and/or after emergence. In the cultivation of leek from seedlings, herbicides can be used shortly after planting.

Foliar treatments should be performed on the basis of the real threat to the crop posed by weeds. Sometimes even a small number of weeds can cause the same reduction in crops as in the case of other species at greater intensity. The decision to perform the herbicide treatment should be guided by the ‘required weed-free period’ or the ‘critical weed competition period’, i.e. the time period when weeds from an economic point of view cause the greatest losses in crops. The required weed-free period for leek grown from sowing is from the emergence of the crop to 3-5 leaves, and for those grown from seedlings, from 3-4 to 7-8 weeks after planting. During this period, care should be taken to assure as little weed as possible; weeds must not be allowed to produce seeds.

It is advisable to use soil-applied herbicides on well-worked soil, with a level surface and suitable moisture. In compact soil with high humus content, it is necessary to use a higher recommended dosage; lower doses are suitable for light soils, and in very light soil it is best to avoid herbicides altogether. In some types of soil with a high content of organic matter, e.g. peat soil, the performance of soil herbicides is low or they produce no effects whatsoever.

The moisture level of the soil has a considerable impact on the performance of soil herbicides; if the moisture level of soil is low, their performance is reduced. Air humidity has a greater impact on foliar-applied herbicides. If humidity is very low, the liquid on the leaves dries rapidly and its penetration of the leaves is limited, and when humidity is very high, the spray liquid may flow off the leaves.

The optimal treatment temperature for most herbicides is in the range of 10-20°C. At higher temperatures, the agents used can damage the leek plants. For some agents, the permissible temperature is higher; for example, graminicides should not be used at temperatures above 27°C. When using graminicides, special attention should be paid to the length of withdrawal periods to prevent residues of these agents from occurring in the consumable parts of the plant.

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 effectiveness of the agents (and the reduction of their consumption) can be improved by the addition of adjuvants (auxiliary agents) to the usable liquid of some foliar herbicides.

Crop rotation after herbicide use

Herbicides vary in duration of action and persistence in the soil which should be taken into account when planning follow-up crops. On herbicide usage labels there are listed species of plants which may be cultivated in the year when a herbicide was applied, after a complete cycle of cultivation of pre-crop plant. Most herbicides do not pose a threat to post-crops, yet some are retained longer in the soil and may cause the emergence of symptoms of phytotoxicity in plants cultivated as post-crops. Before starting cultivation, please refer to the information on the follow-up effects of herbicides given on the product labels. For the cultivation of leek, it is necessary to choose sites following plants where herbicides with a short period of deposition in the soil were used. If the pre-crop plants treated with herbicides are to be removed early, plants for which those herbicides are recommended or species that do not show negative reactions to the active ingredient of the agent used, most often listed on the label of the product, should be grown.

Weed resistance to herbicides and methods of limiting it

The wide-spread use of herbicides results in increased numbers of individuals of a species of weeds resistant to them, which leads to immunisation of the whole species to herbicides. The speed and persistence of the process depends on the frequency of using herbicides of the same chemical groups. The group of herbicides to which monocot weeds more quickly develop resistance includes graminicides used in the cultivation of leek.

The occurrence of weed resistance to herbicides is prevented or significantly delayed, among others, by: crop rotation, alternating use of agents from different chemical groups,

the use of mixtures of herbicides with different mechanisms of action, use of herbicides for weeds during their most sensitive period, use of herbicides in doses guaranteeing the total destruction of weeds, addition of adjuvants to the spray liquid in the case of lower doses, inclusion of mechanical treatments in the weed control system, use of non-selective herbicides before the emergence of the crop.

VI. DISEASES

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Proper selection of the location of leek plantations can greatly contribute to reducing the occurrence of diseases of infectious origin. Therefore, the cultivation of leek should be established in areas free from soil-borne pathogens. These pathogens, apart from leek, often infest other bulbous plants (onions, garlic, chives).

During the growing season, leek can be infected by the following fungal, bacterial, and viral diseases: leek rust, sclerotinia rot, alternaria blight, white rot, pink root rot of leek, leek bacteriosis, and leek stripe.

6.1. List of the most important diseases and their characteristics

In order to detect the first signs of disease early, regular plantation inspections should be carried out, at least once a week, during the period of potential risk, for the presence of: leek rust, sclerotinia rot, or alternariosis. The observations should be recorded in the Integrated Production Notebook.

a) viral diseases:

Leek stripe – pathogen: yellow stripe virus of leek

Yellow stripe virus of leek belongs to the genus *Potyvirus*. It was first detected in leek, but it also infects garlic and onions around the world. It was found that economically less important species belonging to the genus *Allium*, such as: *A. angulosum*, *A. caeruleum*, *A. cyathophorum*, *A. nutans*, *A. scorodoprasum*, *A. senescens* subsp. *montanum* may also be hosts to the virus.

On the leaves of infected leek, initially oblong yellow stripes appear, which can turn grey-green at the end of the growing season. Usually, the disease symptoms are more pronounced on older leaves. The leaf skin of infected plants is thinner than that of healthy plants, and their surface is often undulating. Infested leek become stunted, are devoid of vigor, and may be more susceptible to damage caused by low temperatures. The virus can spread during pruning and the transfer of infected plants. It is transmitted in a non-

persistent manner by many species of aphids. Low temperatures and poor lighting promote the development of the disease. Early infections affect plants more severely than those that occur at the end of the growing season. Infected plants can seemingly recover at higher temperatures.

Prevention and control:

- Sow seeds of at least standard category into a pathogen-free substrate.
- Remove and destroy diseased plants as soon as possible after the onset of disease symptoms (e.g. by burning).
- Do not touch healthy seedlings when discarding diseased plants.
- Disinfect tools and equipment intended for maintenance work.
- Successively protect the leek plantation from pests.

b) bacterial diseases

Bacterial blight – pathogen: *Pseudomonas syringae* pv. *porri*

The disease is common in all areas of leek cultivation in Europe, Canada, and the United States. In recent years, its occurrence has been confirmed in the Netherlands, Italy, Belgium, Australia, Greece, and Korea.

The first symptoms of the disease can be observed in the form of hydrated dark green, oblong spots that form on the tips and edges of the leaf. As the plants grow, the spots change colour from orange to brown and can be elongated in the form of a narrow strip from the tip to the base of the leaves. A characteristic chlorosis can be observed around the spots. On infested young plants, curling and deformation of leaves and yellowing of the central vein are observed. Over time, heavily infested plants wither and die.

The primary source of infection is infected seeds and the remnants of infested plants from the previous crop. As with other diseases caused by the species *P. syringae*, optimal conditions for the development and spread of the disease are a temperature of 13-14°C and high humidity.

Prevention and control:

- Use a minimum 4-year crop rotation.
- Sow seed material of at least standard category into a substrate free from pathogens.
- Perform care treatments during dry, sunny weather.
- Remove and destroy plants with disease symptoms.
- During the growing season, limit excessive sprinkling of plants.

c) fungal diseases:

Leek rust – pathogen: *Puccinia porri*

P. porri is a monoecious pathogen, i.e. the full development cycle takes place on one host. In addition to leek, it also occurs on chives and Welsh onions. This is especially problematic on seed plantations.

The first symptoms of the disease can be observed on the leaves in the form of single, raised, pustule-like yellowish-orange formations, the so-called aecia. They are filled with spores that cause secondary infections. In the initial phase, these changes are surrounded by a light yellow border. After a few weeks, rusty-brown uredia form, and at the end of the vegetation period, spores known as teliospores are produced. Teliospores do not infect; their task is to survive the winter.
The source of infection is infested crop residues left behind.
Strongly infested leaves of the leek turn yellow and die prematurely. Infected plants are characterised by stunted growth and do not reach satisfactory sizes.

Prevention and control:

- Implement a minimum 4-year crop rotation.
- Introduce rust-tolerant/resistant leek varieties into cultivation.
- Sow seeds of at least standard category.
- Avoid excessive nitrogen fertilisation.
- Monitor the plants health during the growing season at least once a week.
- During a risk period resulting from the analysis of weather conditions or the appearance of the first signs of disease, it is recommended to alternatively spray leek plants with fungicides of different mechanisms of action that are registered for IP.
- Thoroughly destroy the residues of infected plants.

Sclerotinia rot – pathogen: *Sclerotinia sclerotiorum*

S. sclerotiorum is a polyphagous fungus infecting many species of crops and weeds. It can contribute to significant losses in the leek crop. Symptoms of the disease are most often visible in the root zone. Infected tissues become watery and soft. In conditions of high air humidity, the lesions are rapidly covered with a white, fluffy, cotton-like mycelium. Within it, you can initially see grey, and later black sclerotia of the fungus. The infestation of the root zone by the pathogen in effect contributes to the yellowing, wilting, drying, and gradual death of the entire plant. Infection by *S. sclerotiorum* on the plantation often occurs in patches, frequently in areas where there are waterlogged spots.
The source of primary infection is most often sclerotia, which, under conditions that allow mycelium to germinate, and in the presence of the host, germinate into hyphae and infect or produce cup-shaped fruiting bodies growing from the ground with sacs filled with ascospores. Spores are carried by the wind and can infect the plant. *S. sclerotiorum* also spreads as a result of splashing fragments of mycelium with drops of water.

Prevention and control:

- Use proper crop rotation, as well as careful and deep ploughing (over 10 cm), which covers crop residues and controls weeds.
- In sites where the disease has occurred, lettuce, tomato and root vegetables should not be grown.
- Avoid sites where water stagnation occurs.
- Sow seed material of at least standard category into a substrate free from pathogens.

- Monitor the plants health during the growing season, with weekly inspections at minimum.
- Remove and destroy plants with disease symptoms.
- For long-term storage, choose healthy, undamaged plants, and ensure that cold rooms and storage containers are thoroughly cleaned and disinfected.

White rot of leek – pathogen: *Stromatinia cepivora* (syn. *Sclerotium cepivorum*)
The pathogen is most often found in areas of intensive cultivation of leek, onion, and garlic. It is a soil pathogen, and its source is most often infected soil, in which fungal sclerotia are located. Another source of the disease can be infested spring onion and garlic cloves.
One of the symptoms of the disease is the inhibition of plant growth, brightening of the leaves, followed by their yellowing and premature dying. Within the basal plate, a white, cottony mycelium is visible, within which the sclerotia of the pathogen are formed in large numbers. They are the size of poppy seeds. The occurrence of *S. cepivora* on the plantation causes localized plant death.
The pathogen infects plants most rapidly when the air temperature is between 17 and 21°C. Temperature below 5°C and above 25°C inhibits the development of the fungus.
Prevention and control:
- Carry out a minimum of 4-year crop rotation, as well as careful and deep ploughing (over 10 cm), which covers crop residues and controls weeds.
- Before planting or after harvesting, it is recommended to sow brassica plants: mustard, canola for incorporation. These plants limit the growth of *S. cepivora*.
- At sites where the disease has occurred, do not grow other allium plants.
- Sow seed material of at least standard category into a substrate free from pathogens.
- Remove and destroy plants with disease symptoms.
- For long-term storage, choose healthy, undamaged plants, and ensure that cold rooms and storage containers are thoroughly cleaned and disinfected.

Alternaria blight of leek – pathogen: *Alternaria porri*
The pathogen occurs most often in the second half of summer, especially when the air temperature is above 20°C and is accompanied by high air humidity. The greatest harmfulness occurs on leek seed plantations, as it causes the collapse of flower stalks and infects seeds. Infested seeds and mycelium overwintering on plant residues are the main sources of leek plant infections.
Symptoms of the disease appear on the leaves in the form of small, whitish lesions. If the air humidity is high (90 %), the spots enlarge, taking the shape of an ellipse with a size of even a few centimetres. These changes become purple and then brown-black. Within them, velvety sporulation of *A. porri* can be observed. Spores are spread by wind and water droplets. One of the symptoms is also the cracking of the leaves along the main vein. Leaf-conducting bundles can be infected, which in effect leads to gradual yellowing and wilting of the leaves.

Prevention and control:

- Use proper crop rotation, as well as careful and deep ploughing (more than 10 cm), which covers crop residues and controls weeds.
- Sow seed material of at least standard category into a substrate free from pathogens.
- Monitor the plants health during the growing season, with weekly inspections at minimum.
- During a risk period resulting from the analysis of weather conditions or the appearance of the first signs of disease, it is recommended to alternatively spray leek plants with fungicides of different mechanisms of action that are registered for IP.

Pink root rot of leek (corkiness of leek roots) – pathogen: *Setophoma terrestris* (syn. *Pyrenochaeta terrestris*)

The pathogen is most often found in areas where leek, onions, garlic, and chives are intensively cultivated. *S. terrestris* is a soil pathogen that affects the roots of plants. They become initially pink, and then dark purple. With high pressure, the infested roots die off, which in turn can contribute to an accelerated end to vegetation. The leek leaves dry up, and the plants are stunted. In seed plantations, the pathogen can cause seed shoots to topple even before the seeds reach harvest maturity.

The development of the fungus is favoured by temperatures of 24-26°C and the cultivation of leek on low-humus catchment soils.

Prevention and control:

- Use a minimum 4-year crop rotation.
- Organic fertilisation carried out in the autumn, in the year preceding the crop, limits the growth of the fungus.
- Sow seed material of at least standard category into a substrate free from pathogens.

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. In Poland, there is no such system for leek. Prevention and control of pests in leek crops should be carried out on the basis of signalling of pathogens and programmes for the

protection of vegetables (e.g. leek) 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.

Types of disease prevention

Preventing the occurrence and spread of harmful organisms in leek crops involves 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.
- Regular observation of the leek plantation and identification of harmful organisms, as well as determination of the intensity and area of its presence.

6.2. Non-chemical methods of controlling leek diseases

Agrotechnical method

Crop rotation and crop sequencing are the basis for maintaining proper microbiological balance and soil health, as well as limiting the excessive multiplication of soil-borne pathogens, e.g. *S. sclerotiorum*, *S. cepivora*, *S. terrestris*.

The cultivation of leek in monoculture promotes the spread of pathogens of soil origin. The correct crop rotation should take into account those arable plant species that are not hosts to the harmful organisms present at the site. In crop rotation involving leek cultivation, account shall be taken of at least a 4-year rotation of plants. Do not grow leek on plots previously used for onions, garlic, chives, or oats. However, a good site for them is left by, for example, peas, beans, cauliflower, cucumber, carrot, and tomatoes. In addition, when cultivating leek, weeds should be thoroughly destroyed and varieties resistant to certain diseases should be introduced into cultivation.

Location of plantations. Choosing the right location for the plantation may limit the spread of diseases that pose a risk to leek crops (e.g. sclerotinia rot, white rot, pink root rot). To limit the possibility of certain leek pathogens, avoid sites where leek for seeds is grown nearby, as well as fields surrounded by shrubs and trees, located near water bodies.

Timely performance of soil mechanical tillage such as: ploughing, cultivating, harrowing or subsoiling has a significant impact on the elimination of water stagnations in the field and reducing the occurrence of diseases of soil origin (e.g. sclerotinia rot). It should also be noted that soil-borne pathogens can be transferred on wheels of machinery and growing tools to adjacent fields.

***Regulating the times of sowing and harvesting*.** In the case of leek, the regulation of sowing/planting dates is of little importance in terms of avoiding/reducing the occurrence of pathogens.

Fertilisation. Proper fertilisation of leek has a significant impact on health of plants, increases their defensive capabilities and regenerative capacity. Organic fertilisation with manure and compost increases the content of beneficial microorganisms stabilizing the microbial balance of the soil and reduces the occurrence of infectious soil pathogens, e.g. *S. terrestris*.

***Weed control*.** Many species of weeds are hosts to pathogens, e.g. *S. sclerotiorum*. In addition, the weedy plantation is conducive to the occurrence of rust or leek alternariosis. Many species of weeds are also hosts for pathogenic bacteria and viruses. Keeping the leek plantation free of weeds is one of the basic principles of hygiene and phytosanitary treatments.

***Phytosanitary hygiene measures*.** Removal of crop residues and fragments of infected plants is an important treatment in preventing or reducing the occurrence of most diseases of fungal, bacterial, and viral origin as they are the place of overwintering of many pathogens of vegetable plants, e.g.: *S. sclerotiorum*, *S. cepivora*, *S. terrestris*.

Cultivation method

An important criterion for the selection of varieties in integrated production is their resistance or tolerance to the most dangerous diseases, e.g. leek rust, low susceptibility to adverse climatic factors, the formation of a strong root system, the ability to maximize the use of nutrients, and tolerance to cold (high frost resistance). The use of the characteristics of available leek varieties in cultivation allows for obtaining a commercial yield at the appropriate level.

Biological method

This method is effectively and widely used in vegetable crops under cover, and to a lesser extent in field crops. For biological protection of leek, it is recommended to use available preparations based on antagonistic organisms, which destroy or limit the development of pathogens of fungal origin.

6.3. Chemical measures to fight diseases

Prevention method:

Taking action in the form of seed treatments, watering of seedlings, use of soil granules before the appearance of disease perpetrators 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 consists in the application of measures during the period of the appearance of the first symptoms of the disease on individual leek plants on a given plantation, either in the immediate vicinity or according to the indications of alerting devices. This mainly applies to rust and alternariosis of leek.

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

Growing leek in a system of integrated production does not preclude the use of fungicides to control diseases of infectious origin. Such agents 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 of control for multiple diseases simultaneously. The withdrawal period is very important. A short withdrawal period should be provided for fungicides used for interventional treatments during the period when the leek reaches consumer maturity. Often, the same product has different withdrawal periods defined for different vegetable species. The leek requires careful and timely preventive protection from the period of emergence/planting of seedlings to the end of vegetation.

VII. PESTS

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7.1. Description of harmful species, prevention and control

Below are listed pest species occurring annually and occasionally on leek plantations, along with options for preventing their occurrence and methods of control. The most important of these are: tobacco thrips (order — Thysanoptera), onion leaf miner (order — Lepidoptera), and cutworms (order — Lepidoptera). Also important is the leek leaf miner (order – Diptera), which is most abundant in the southern and south-eastern part of Poland, but is also becoming more and more common in the central part of the country. Onion weevil (order — beetles) and onion flies (order — Diptera) may also pose a temporary or local threat to leek crops, and if they are abundant in the soil of the field, also grubs (beetle larvae).

Tobacco thrips (*Thrips tabaci* Lind.)
family: Thripidae

Description of damage. Both larvae and adults puncture plant cells and suck the juice out of them. The damaged cells fill with air, which is visible in the form of initially local, silvery-white spots located along the main vein of the leaf, eventually covering its entire surface.

Intensive feeding of thrips results in the drying of leaves and inhibition of plant growth. In addition, thrips can be vectors of dangerous viruses affecting allium vegetables.

Pest description. Adults are 0.8 to 1.3 mm long, with an elongated body, of varying body colour, ranging from light yellow in spring and summer to brown in autumn. The wings are narrow, surrounded by fringes, and at rest are folded along the body. The antennae are 7-segmented, with the first segment being light and the others dark. The larvae are yellow in colour, resemble adults in appearance, but have no wings and are less mobile.

Biology outline. Adult specimens overwinter in the top layer of the soil (up to 10 cm deep) and on plant residues, as well as on leek left in the field for wintering, on winter allium vegetables, on wild plants near plantations, or in storage and under cover. In early spring, they leave their winter hideouts and begin feeding, initially on wild-growing plants or overwintering allium vegetables, then fly to the leek plantations where they feed and reproduce. Tobacco thrips, feeding on leek until autumn, develop from 4 to 6 generations.

Monitoring and threat thresholds. In the initial period of thrips settlement in the leek, yellow or blue sticky boards located in the marginal part of the plantation can be used for monitoring. These boards should be placed at a height of approximately 20-30 cm above the plants, where they capture adult insects that are either invading or already present on the plantation. The basic method of monitoring is to inspect the leaves (with particular emphasis on their angles), in search of larvae and adults. Inspections of the plantation are conducted from June to August, at least once a week, by examining plants growing along a 1-meter section of the row in 5 randomly selected locations on the plantation. The threat threshold is defined as 6-10 individuals on a single plant in the 3-5 leaf stage per 1 linear meter of row.

Prevention and control. A set of post-harvest soil tillage operations, including deep pre-winter ploughing, helps reduce the number of thrips wintering in the top layer of the soil and on plant residues. Destruction of weeds within the plantation and on its outskirts reduces the availability of host plants for the pest. Avoid the vicinity of onion plantations and crops under cover. Natural enemies of thrips may also play a role in reducing their numbers, including predatory true bugs from the Anthocoridae family (genus *Orius*).

Registered plant protection products should be used to control thrips, with priority given to biological (entomopathogenic fungi) and biotechnical preparations. An important role in the effectiveness of treatments is played by repeating the spraying after about 7-10 days, which allows for the destruction of adult insects that emerged from the soil after pupation and were not yet present on the plants at the time of the first treatment. After treatment, monitoring should be continued and action should be taken again if the threat threshold is reached.

Onion leaf miner (*Acrolepiopsis assectella* Zell.)

family: Acrolepiidae

Description of damage. The caterpillars damage the young, central leaves of the leek by consuming the mesophyll from underneath, but usually leave the upper epidermis intact, resulting in oblong, whitish, membranous lesions (windows). The skin within them dries and

cracks over time, creating irregular holes. Damaged leaves twist. Plant growth is weakened. Damaged plants lose their commercial value and, if left in the ground, they overwinter poorly.

Pest description. Moths are 6 to 8 mm long and have a wingspan of 10 to 12 mm. The front wings are grey-brown with white spots, while the hind wings are grey with a long fringe on the edges. White, oval eggs are 0.3 mm long. The caterpillars are light cream, with characteristic dark warts on the body and a brown head, 10 mm long. The brown pupa, 6-8 mm long, is surrounded by a cocoon of mesh yarn.

Biology outline. The moth develops 2 to 3 generations during the growing season. The females overwinter on the leek left in the field for wintering, on plant resides, in hiding places in the bark of trees, on field margins and wastelands, in storage rooms and similar places. In spring, when the average air temperature reaches 7°C, the females leave the wintering sites and flock to seed plantations or winter crops of allium vegetables. Eggs are laid on the top surface of the youngest leaves. Pupation takes place on plants. In the production of leek, the greatest economic damage is caused by the second generation of the pest, whose flight usually occurs at the turn of June and July (or earlier, in favourable air temperatures), with caterpillar feeding taking place during June and July. The flight of the third generation takes place at the turn of July and August.

Monitoring and threat thresholds. The flight of onion leaf miner can be monitored with the help of pheromone traps, placed in the marginal part of the plantation, to which male pests are caught. In addition, from June, at least once a week, the young leaves of plants should be inspected for signs of pest foraging. 10 additional plants are inspected in 3-5 locations on the plantation. An average of 2-5 leaf (window) lesions in a sample of 10 plants is considered to be a threat threshold.

Prevention and control. The number of wintering forms of the pest may be affected by deep incorporation of crop residues. Locate leek plantations in spatial isolation from other allium vegetable crops attacked by onion leaf miner, including onions and garlic. Plants damaged by the pest should not be left to overwinter, as they will serve as a source of infestation for new crops. Proper crop rotation (avoiding the annual cultivation of allium vegetables attacked by the pest) prevents its occurrence at a given site. The natural enemies of onion leaf miner caterpillars are parasitic Hymenoptera (Parasitica), particularly from the family Ichneumonidae. The presence of natural enemies in the vicinity of vegetable crops, including leek, can be supported by leaving field scrub or creating food-rich areas for them, such as flower strips. Registered plant protection products should be used to control the onion leaf miner. Since females begin laying eggs on the plantation from plants in its marginal parts, if the presence of the pest is confirmed on the periphery during monitoring, the treatment may be limited to this part of the crop only.

Leek leaf miner (– *Phytomyza gymnostoma* Loew.)
family: Agromyzidae

Description of damage. Females puncture the leek leaves and feed on the juice coming out of the damaged tissues. They also lay eggs in feeding areas. As a result, rows of white spot discolourations appear along the leaves; this does not cause significant losses, although it has an alerting function. The feeding of the first generation larvae causes transient deformations of young plants, which are, however, regenerated as the plants grow. The greatest damage is caused by the larvae of the second generation, which bore tunnels running down the pseudostem (white part) of the leek. These damages turn brown over time. They are often inhabited by pathogens.

Pest description. Adult Diptera range in length from 3.3 to 4.2 mm, with males being smaller in size than females. The head is yellow, the body is grey with yellow stripes along the sides of the abdomen. Milky white, oblong eggs measure 0.5×0.2 mm. Legless larvae, up to 5 mm long, initially whitish, turn yellow over time. The pupa is in the form of a dark brown puparium 3-4 mm long.

Biology outline. The pest develops two generations in a season. They overwinter in crop residues, in the leek left in the field for wintering, in mounds or storage facilities. Larvae can also overwinter, pupating only in the spring of the following year. The start date of the first generation of Diptera depends on the weather. It usually starts in the second half of April and continues through May or until early June. After about two weeks of feeding, the larvae form a diapause cocoon in the ground. The flight of the second generation of Diptera begins in August and, in favourable weather conditions, can last until October. The larvae feed until November.

Monitoring and threat thresholds. In May, and especially in July and August, plants should be inspected for damage caused by females feeding and laying eggs on the leaves. At least once a week, 10 consecutive plants should be inspected in 3-5 randomly selected locations within the plantation. The threat threshold is the finding of an average of 8-10 points of leaf puncture by females per 1 m^2 of crops.

Prevention and control. Careful mechanical cultivation of the soil after harvesting, and in particular deep pre-winter ploughing, destroys plant residues along with the wintering pupae. It is recommended to maintain the spatial isolation of leek plantations from the cultivation of other allium vegetables inhabited by the pest, observe proper crop rotation, and locate plantations in open areas, as places sheltered from the wind are more frequently inhabited by leaf miners. Plants from healthy, well-grown seedlings more easily regenerate damage caused by the first generation of larvae. On smaller areas, it is possible to cover early varieties, planted for the summer harvest, with crop cover. Reducing the losses caused by the first generation of the pest is also possible by delaying the date of planting seedlings in the field. Only pest-free vegetables should be used for storage in mounds and storage facilities; similarly, damaged leek should not be left to overwinter in the ground.

Onion weevil (*Ceutorhynchus suturalis* (Fabr.))
family: Curculionidae

In the cultivation of leek, onion weevil poses a negligible threat, appearing only locally.

Description of damage. Both beetles and larvae are harmful. Females bite small holes in the leaves, arranged in rows along the leaves, into which they lay eggs. Hatched larvae bore into the tissue from the inside, leaving the skin intact, which is visible in the form of narrow, oblong windows, similar to damage done by onion leaf miner.

Pest description. Beetles reach a length of approximately 3 mm; they are black, covered with grey scales, and have a lighter line on the dorsal side. The larvae are about 7 mm long, legless, yellowish with a clearly marked brown head.

Biology outline. The pest develops one generation a year. Beetles overwinter in the litter, on field margins and under the clumps of soil, in the furrows left in the field for wintering. On the plantation, leek can appear from April to the beginning of June. In June, females lay eggs. After about two weeks, the larvae hatch and begin to feed. After two weeks, fully grown larvae leave the plants and descend to the ground to a depth of 2-3 cm, forming a chamber in which they pupate. Beetles descend for wintering after complementary feeding.

Monitoring and threat thresholds. Monitoring involves inspecting plants for damaged leaves. Usually, there is no need to combat this pest. The threat threshold is the finding of 2-5 bitten 'windows' in the leaves on a further 10 plants.

Prevention and control. Preventive measures include a set of soil tillage practices, including deep winter ploughing, which allows for the destruction of beetles wintering on plant residues and in the mulch layer. Additionally, it involves maintaining the spatial isolation of leek cultivation from nearby onion plantations. In the case of a large infestation, it is advisable to perform a treatment using one of the registered insecticides.

Onion fly (*Delia antiqua* Meig.)
family: Anthomyiidae

In the cultivation of leek, the onion fly is less significant than in the production of onions and garlic, although locally it can cause losses.

Description of damage. The harmful stage is the larvae, whose first generation feeds on the roots and heel of the leek, causing inhibition of growth and wilting of young plants. The second generation of larvae feeds on the above-ground parts of plants, creating tunnels in the edible part. Adult Diptera feed on the nectar of flowers.

Pest description. Adults have a metallic glossy, olive-grey body and reach a length of 6-7 mm. White, elongated eggs, 1.2 mm long, are laid under soil clumps near or directly on the host plant. The larvae are legless, whitish-yellow, 7-10 mm long.

Biology outline. Two generations occur a year. This Diptera overwinters in the pupal stage in the soil at a depth of 2-12 cm. The flight of the first generation begins in May and June, while the second generation starts in mid-July and lasts until the end of August.

Monitoring and threat thresholds. Monitoring involves counting eggs laid by the onion fly into the soil at the base of plants; it is also possible to use yellow sticky boards to catch incoming adult insects.

Prevention and control. Preventive measures include mechanical soil cultivation, in particular deep ploughing, in order to destroy the pupae wintering in the soil at a depth of 10-20 cm – the plough, inverting the soil, extracts part of the wintering pupae to its surface, where they are eaten by birds, dry out or freeze. Avoid establishing leek plantations near onion crops, for which the onion fly is a very common pest. It is necessary to observe the correct crop rotation, i.e. refraining from growing allium vegetables more often than every 3-4 years in a given field. It is advisable to destroy weeds within the plantation and on its outskirts before they bloom, as they are a source of food for adult insects and can attract them. An important role, especially in limiting the second generation of the pest, is played by predatory beetles of the Carabidae and Staphylinidae family.

Cutworms (*Agrotis* spp.)
family: Noctuidae

Among the many species present in Poland, in vegetable crops, including leek, the most abundant is the **turnip moth** (*A. segetum* Den. et Schiff.). The following can be present in slightly lesser intensity: **heart and dart** (*A. exclamationis* (L.)), **spotted cutworm** (*A. ipsilon* (Hüfnagel)) and **dark sword-grass** (*Agrotis c-nigrum* (L.)). These are polyphagous pests that feed on many crops and wild plants.

Description of damage. The harmful stage consists of caterpillars, which create large, irregular pits in plants. Young caterpillars feed on the above-ground part of plants, often also undercutting them, which leads to patchy die-off. In the spring, a single caterpillar can destroy from several to a dozen-or-so plants. On the other hand, the older ones stay in the soil during the day, where they damage the underground parts, and at night they come to the surface, feed on the above-ground parts, often also undercut and overturn the plants, and then eat them or drag them into underground hiding places.

Pest description. Turnip moths have wings with a span of up to 45 mm. The front wings are darker than the rear, with a pattern in the form of round, oval, and kidney-shaped spots. The caterpillars of individual species differ in size and colouration. Turnip moth beetles are 45-50 mm long, dark olive with a greenish tint and darker lines along the body. The caterpillars of the heart and dart, measuring 35-50 mm in length, are brown-grey with a bright line along the body; dark sword-grass - up to 35 mm long, grey-green or brown; spotted cutworm - up to 50 mm long, dark green, matte, with a reddish line on the dorsal side. The pupa is closed and red-brown.

Biology outline. Cutworms develop from 1 to 2 generations per season, depending on weather conditions. Caterpillars or pupae overwinter in the soil, at a depth of up to approximately 25 centimeters. In spring, usually in April, when the soil temperature exceeds 10°C, the caterpillars leave the overwintering site and begin feeding on the plants, after which they descend into the soil for pupation. Moth flights begin at the turn of May and June. Adult insects are active at dusk and at night. The caterpillars hatch after 5-15 days and feed on the plant during the day. The older ones are active mainly at night, and during the day they hide underground, where they damage the underground parts of plants.

Monitoring and threat thresholds. Assessment of threat caused by cutworms is carried out in the autumn, in the year preceding the establishment of the crop, when it is still possible to carry out a complete set of soil tillage operations, allowing the reduction of the number of wintering forms of the pest. The threat threshold is the detection of 5 caterpillars in an area of 1 m^2 of the field. In the growing season, from the beginning of May to the end of September, the flight of moths (primarily turnip moth) should be monitored using pheromone traps, with 2 traps per hectare, placed above the tops of plants. Pheromone traps shall be inspected at least once a week, each time recording the number of pests caught. In addition, at least once a week, plants should be inspected for the presence and effects of caterpillar foraging. The detection of 1 caterpillar per linear meter of the row is the basis for carrying out the treatment.

Prevention and control. In order to reduce the overwintering stages of cutworms after harvesting the preceding crop, it is recommended to carry out a full set of soil tillage operations, in particular shallow ploughing and deep pre-winter ploughing, as a significant number of caterpillars and pupae are eliminated during these treatments. In areas of high threat from cutworms, it is also possible to plough wasteland, which can be a reservoir of the pest. With a high prevalence of the pest, it is possible to consider abandoning the establishment of leek plantations in a given field. In addition, during the growing season, it is recommended to destroy weeds on the plantation and in its vicinity before they bloom, as they are a source of food for adult moths. In reducing the number of cutworms, their natural enemies may play a role, including predatory beetles of the Carabidae family and Hymenoptera (from the Ichneumonidae Braconidae and other families) and Diptera from the Tachinidae family, whose larvae are parasitoids of caterpillars.

When the threat threshold is reached, spraying with insecticides registered for the control of cutworms should be carried out, with priority given to biological preparations (entomopathogenic bacteria). Treatments should be carried out in the evening. For older stages of caterpillar development, the best results are achieved by spraying at night, between 1:00 and 4:00.

Grubs (larvae of beetles from the Scarabaeidae family)

family: Scarabaeidae

As in other vegetable crops, in leek production as well, the numerous occurrence of polyphagous beetle larvae in the field can cause significant losses. The greatest damage is caused by the grubs of the following species: **Maybeetle** (*thrips* (*Melolontha*) *melolontha* (L.)), **summer chafer** (*Amphimallon solstitiale solstitiale* (L.)) and **garden chafer** (*Phyllopertha horticola* (L.)).

Description of damage. Grubs, present in the soil throughout the growing season, damage parts of underground plants by biting irregularly shaped holes in them or eating small roots whole. Damage to the tissues of underground organs can be a point of entry for pathogens. Plants with a damaged root system grow less or wither. Adult beetles feed on the above-ground parts of plants.

Pest description. The grubs are arched, with a white body, a thickened blue end, and a brown head. They have three pairs of legs. The larvae of the garden chafer and summer chafer reach a length of up to 20 mm, while the maybeetle larvae are larger (up to approximately 50 mm in length). Maybeetle is 20-30 mm long, has a black prothorax and brown wing elytra, with white triangles on the sides of the abdomen. Summer chafer 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 prothorax and rusty-brown elytra covered with hairs.

Biology outline. In the garden chafer, the development of larvae lasts 1 year, in the summer chafer 2 years, and in the maybeetle most often 4 years. Larvae and beetles overwinter underground. Mass outbreaks of cockchafers occur from the end of April to the end of May, while June beetles and garden chafers appear 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. The larvae, after reaching stage L4, which usually occurs at the end of summer or in autumn, descend deeper into the soil, where they pupate.

Monitoring and threat thresholds. The best time to assess the risk from grubs is the autumn of the year preceding the establishment of the leek plantation, when it is still possible to carry out a full set of soil cultivations. For this purpose, soil pits measuring 100×100 cm (1 m^2) are made, to a depth of 25 cm. The excavated soil is then sieved, and the larvae present in it are counted. The threat threshold during this period is the finding of an average of 2 grubs per single soil sample taken from an area of 1 m^2. During the growing season, the plants should be inspected in several places for signs of damage to the root system by grubs and the presence of larvae in the soil. The threat threshold is taken to be 1 grub per 1 linear meter of the row.

Prevention and control. The main role in combating grubs is played by agrotechnical methods. The abundance of larvae in the soil is significantly limited by shallow ploughing, deep pre-winter ploughing, and cultivation. The population of grubs is also reduced by including in the crop rotation plants that are not attractive to them for food (mustard) or harmful due to the content of toxic substances in the roots (buckwheat). During the vegetation period, after exceeding the threshold of danger, the treatment of spraying or watering plants with biological agents (parasitic nematodes) or preparations of plant origin (e.g. tansy extract) may be applied.

7.2. Methods of monitoring pests in leek cultivation

Proper monitoring, carried out at the right time, with the appropriate frequency and using the recommended methods for a given pest, plays a key role in integrated plant production, as it allows early identification of pests threatening crops and assessment of their risk. This provides the basis for carrying out the treatments at the most appropriate time before the pest takes over the plantation and causes significant losses. Among the methods used in pest monitoring, observation forms the basis, which can be supplemented with aids such as coloured sticky boards or traps with sex pheromone dispensers.

The visual method involves regular inspections of plants on the plantation, in search of pests (eggs, larvae, or adult forms) or damage caused by them. A prerequisite for the success of this monitoring method is knowledge of the appearance of the pest, the approximate date of its occurrence in the crop, the development cycle (so you know where and which developmental forms of the pest to look for) and the type of damage it causes to plants. The visual method is used for monitoring all the most important leek pests, including tobacco thrips, onion fly, leek leaf miner, and cutworms. A 10x magnification magnifier or binoculars can assist in plant inspections, making it easier to spot small insects on the surface of plants, especially larvae and adult female tobacco thrips.

In the case of pests whose development cycle is related to the soil environment (cutworms and grubs), observation may require **digging up the soil or making excavations and taking samples**. They are then sieved and the pests present are counted. Soil larvae are also visible during soil cultivation, e.g. ploughing.

Precise monitoring of the flight of some moths is enabled by **pheromone traps**. Currently, sex pheromone dispensers are available for onion leaf miner and for cutworms — turnip moth, heart and dart, spotted cutworm and dark sword-grass. These traps should be inspected at least once a week, and the males caught should be counted. In the case of tobacco thrips, **yellow or blue sticky plates** shall be used, which are placed above the plants. Blue is more effective in capturing thrips and attracts fewer non-target insects, including beneficial insects. However, it should be remembered that adhesive boards mainly capture adult thrips capable of flight.

Table 2. Threat thresholds for the most important pests present on leek plantations

Pest species	**Threat threshold** *	**Inspection and control date**	**Harmful stage**
Tobacco thrips	6 to 10 individuals per plant	June – July	Adult insects, larvae
Onion leaf miner	From 2 to 5 bites (windows) on the leaves of 10 consecutive plants	June	Caterpillars
Leek leaf miner	Determination of an average of 8-10 leaf puncture points by females per 1 m^2 of cultivation	July — August	Larvae
Cutworms	4 caterpillars per 1 m^2 of cultivation	March-September	Caterpillars
Beetle larvae of the Scarabaeidae family — grubs	5 grubs per 1 m^2 of crops up to a depth of 20 cm	March-September	Larvae

* Threat thresholds according to Szwejda (2015)

7.3. Indirect pest control methods

A key role among methods of pest prevention in integrated leek production is played by proper agrotechnics, with careful and timely soil cultivation at the forefront. **Mechanical tillage**, and in particular deep pre-winter ploughing, control the overwintering stages of most pests, including cutworms, harmful Scarabaeidae beetles, leek leaf miners, onion weevil, and onion fly. They can also partially reduce the baseline population of tobacco thrips and onion leaf miner after wintering. **Balanced fertilisation** serves to strengthen the mechanical tissues of plants, which makes them less susceptible to pests. **Use of correct crop rotation**, which involves the introduction of non-pest host plants into the rotation, prevents their accumulation in a given area and is a very important factor in reducing the occurrence of pests. It is also important to cultivate on a given site (as a main crop or catch crop) plants that are not an attractive source of food for pests or contain substances toxic to them (e.g. mustard and buckwheat in limiting grubs). **Weed control** reduces the availability of food plants or habitats for the wintering of certain pests. This is important for polyphagous pests such as the tobacco thrips, but also for species whose adult insects feed on nectar and are attracted by flowering plants (onion fly, cutworms). It is also important to consider the **appropriate location of the plantation**, which should take into account potential sources of pests in the close surroundings or places conducive to their development. In particular, it is recommended to avoid the proximity of crops of other species of the Allioideae family, which are attacked by pests common to leek. Thus, for example, the close proximity of an onion plantation poses a greater risk of infestation of leek by tobacco thrips, onion leaf miner, onion fly, or onion weevil. The presence of thrips is also facilitated by the proximity of crops under shelter, while idle land may constitute a significant reservoir for cutworms. In turn, for the protection of leek crops from the leek leaf miner, the location of plantations in the open air is important, as places sheltered from the wind are more often inhabited by this pest. In some cases, pest pressure can be reduced by appropriate **selection of varieties and control of the date of sowing or planting of seedlings**. By delaying planting, the losses caused by the first generation of the leaf miner can be reduce.

Table 3. Agrotechnical methods for the protection of leek from pests

Pest	**Protection methods**
Tobacco thrips	Soil cultivation (destruction of crop residues); combating weeds; spatial isolation from onion crops and under cover
Onion leaf miner	Soil cultivation (destruction of crop residues); spatial isolation from other allium vegetable crops; correct crop rotation; leaving pest-free plants for overwintering
Leek leaf miner	Careful soil cultivation, including deep pre- winter ploughing; spatial isolation from other allium vegetable crops inhabited by the pest; location of the leek plantation in the open air; correct crop rotation; storing in mounds and pest-free vegetable storage facilities, not leaving damaged vegetables to overwinter in the field

Onion weevil	Careful soil cultivation, including deep pre- winter ploughing; spatial isolation from nearby onion plantations
Onion fly	Careful soil cultivation, including deep pre- winter ploughing; spatial isolation from nearby onion plantations; correct crop rotation, weed control
Cutworms	A full set of soil tillages, including deep pre-winter ploughing; spatial isolation from wasteland; weed control
Grubs	A full set of soil tillages, including deep pre-winter ploughing; spatial isolation from wasteland; crop rotation including non-food-attractive plants

The totality of actions taken to **protect natural enemies of pests**, whose activity on and around the plantation prevents the excessive growth of pests, is also significant. The larvae of parasitic Hymenoptera of the Parasitica suborder limit the population of caterpillars of moths feeding on plants. Predatory beetles, including representatives of the Carabidae family, combat cutworms and onion fly larvae. Different-winged bugs from the Anthocoridae family are the natural enemies of thrips. The quantity and quality of a vegetable crop depends significantly on the presence of pollinating insects such as Hymenoptera, dipterans, and butterflies. For economic reasons, the most important group of Hymenoptera are bees, among which honeybee, bumblebees, and wild bees (e.g. the red mason bee) can be distinguished. The presence of pollinators in the area of vegetable crops, including leek, can be supported by leaving or creating food-rich places for them, e.g. flower strips, as well as shelter and nesting places such as “houses” for red mason bees and boxes or mounds for bumblebees in the number of at least 1 per 5 ha, and in the case of larger plantations – several pieces. The preferred place to set up houses for mason bees and bumblebees is at the edge of the plantation so that their exits face south.

7.4. Direct pest control methods

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 pests, food baits can be laid out. Catching moths of the Noctuidae family can be done using catch traps and self-traps, while non-woven covers can be used to protect plants from the leek leaf miner.

Use of zoocides

The decision to use zoocides should be made based on the results of regular monitoring, taking into account the harmfulness thresholds. In integrated production, plant protection products with the shortest withdrawal period should be used, especially in the case of interventions carried out during the period when vegetables reach consumer maturity, and selective preparations, i.e., those acting on a specific group of organisms.

Biological preparations (e.g. entomopathogenic fungi, parasitic nematodes) and biotechnical preparations (e.g. vegetable oils and essential oils, natural substances disrupting the developmental cycles of pests) shall take precedence over chemical agents. Biological plant protection products must be used at least once per season (primarily before harvest), which should be confirmed by the purchase invoice of the product.

Principles of zoocide use

- Only plant protection products registered for leek cultivation should be used, in doses and in a manner consistent with the recommendations on their label.
- Biological or biotechnical preparations shall have priority over chemical plant protection products.
- Where possible, the use of broad-spectrum preparations should be avoided by replacing them with agents that are selective for beneficial entomofauna.
- In order to prevent the resistance of pests and the compensation of resistant forms in a given area, the principles of rotation of active substances of plant protection products should be respected, i.e. avoiding repeated use of the same substance or substances with the same mechanism of action on the same harmful organism.
- The decision to perform a treatment with a plant protection product should be made based on the results of individual monitoring, taking into account the threat thresholds, if they have been developed for a given pest. In addition, treatments should be carried out as early as possible after the pest population has reached the threshold of harmfulness in order to ensure the most effective reduction of its abundance and to prevent its further spread within the plantation.
- Plant protection products should be used under conditions that are optimal for their effectiveness, ensuring the highest biological activity at the minimum recommended dose and reducing the risk of symptoms of phytotoxicity on plants. For most insecticides, the recommended air temperature during spraying is in the range of 18-24°C. On days with high air temperature, treatments should be performed early in the morning or in the afternoon and evening.
- Measures should be taken to prevent the drift of the working fluid to areas other than the target, in particular by spraying at the optimum wind speed. Wind speed during the treatment in open space must not exceed the maximum value specified by the regulation of the Minister for Agriculture and Rural Development.

7.5. Actions to protect beneficial organisms

- Where possible, priority should be given to selective plant protection products for beneficial fauna over broad-spectrum preparations.
- In a situation of low pest prevalence, when it does not threaten a significant reduction in yield and with a large population of its natural enemies, the treatment may be omitted.
- The use of plant protection products may be restricted solely to areas where pests occur within plantations, e.g., the periphery.
- The treatment with the plant protection product should be carried out as early as possible after the pest population has reached the threshold of danger, before its

natural enemies appear in greater numbers on the plantation, for whom the preparation may be harmful.

- It is absolutely necessary to avoid the use of plant protection products during the activity periods of pollinators, and therefore to perform treatments before or after their flights. Poisoning during the spring period is particularly dangerous for wild bee populations, as females are searching for nesting sites; their death prevents the development of the next generation. In addition, honeybee hives should be protected from exposure to the working liquid of plant protection products. Unintentional or intentional acts resulting in bee poisoning is punishable by a financial penalty. The correct use of plant protection products is supervised by the Poviat Inspectorates of Plant Health, which accept reports of bee poisoning and carry out proceedings as a result of which the producer becomes obliged to cover the losses.
- It is recommended to take measures to provide habitats or food resources for beneficial organisms, including natural enemies of pests. These may include the establishment of flower strips on the outskirts or directly on the plantation and the protection of field margins, mid-field refuges, and other natural or semi-natural elements of ecological infrastructure (e.g. ponds, heaps of stones).
- Pro-environmental measures should create nesting sites for wild pollinators, such as solitary bee houses or mounds and bumblebee boxes.

VIII. COLLECTION AND STORAGE OF LEEK

Dr Maria Grzegorzewska

8.1. Factors influencing the storage of leek

Leek can be grown from seedlings as well as from sowing directly into the ground. Taking into account the equalization of yield and greater ease of mechanical harvesting, for large-scale farms it is recommended to grow from seedlings on ridges.

When planning the storage of leek, it is necessary to grow late varieties, forming a thick stem, with a long bleached part. Leek intended for wintering in the ground is harvested only in the spring and directly marketed. If another method of storage is planned, then leek is harvested in late autumn. Large-scale farms harvest leek mechanically, using tractor-mounted or self-propelled combine harvesters. It is recommended that the material intended for long-term storage be placed in crates manually, while selecting and removing diseased and damaged plants. Leaving soil residues on the plants is not a mistake and even contributes to reducing plant wilting. For short-term storage of leek in a cold store, a temperature of 0°C is recommended, while for longer storage (3-4 months), a temperature of -1.5°C is advised. Further lowering the temperature causes frost damage to the plants. It is also necessary to maintain a high relative humidity of 96-98 %.

Leek is sensitive to ethylene, so it should not be stored together with fruits (apples, pears) that emit this gas.

The cause of significant losses in the storage of leek is also storage diseases, particularly grey mold, caused by the fungus *Botrytis cinerea*. Reducing the development of fungal diseases can be achieved by carrying out regular plant protection during the growing season and by cleaning and disinfecting packaging and storage rooms.

8.2. Methods of storing leek

Leaving plants in the field

This is the easiest and cheapest way to store leek through the winter. For this purpose, varieties with high frost resistance are selected. This method is recommended especially in areas with mild weather conditions during winter. After the soil has frozen and the plants have been covered with snow, access to the material in the field is difficult. Plants can only be harvested in the spring. Weaker plants often freeze, but the remaining ones resume vegetation in spring and are commercial material until they begin to develop flowering shoots, that is, until mid- or late May. During harsh and snowless winters, a marked improvement in the results of storing leek in the field can be achieved by using flat non-woven covers or perforated film.

Trenching

Another method is trenching, which can be performed on the bed, in a ditch, as well as in cellars and dugouts. For trenching on the bed, it is required to first select the area where water does not accumulate and delineate strips of land with a width of 1.5-3.0 m. Shallow grooves are then made across the strips, in which the plants are placed immediately after being dug up (in October or early November), positioned closely, one next to the other. Then the roots and bleached parts are covered with earth, forming a bed raised above the surface of the ground to a height of approximately 10-15 cm. In such a bed, plants are not exposed to flooding during heavy rainfall or snowmelt. It should be remembered that trenched plants better withstand the winter period if, before the onset of frosts, they can still root in a new place. Using trenching on the beds also hinders access to the leek after the ground has frozen. Usually, the accumulated stocks can be used only at the end of winter or in early spring.

When starting to dig trenches in ditches, strips of earth with a width of 1.5-2.0 m are also designated, in which the soil is excavated to a depth of approximately 20 centimetres. In the resulting trench, plants are also placed closely next to each other. Roots and bleached parts can be slightly covered with soil or left uncovered. A makeshift roof is constructed over the entire trench, onto which straw, haulm, or snow is placed during severe frosts. This method of excavation allows for the use of accumulated material during the winter.

In cellars or dugouts, after placing the plants closely next to each other, the roots and bleached parts are covered with moist sand, which should be systematically sprinkled during storage, and the temperature in the room should remain at 0-1°C. During winter, the outer leaves of the stored plants lose their fresh appearance, and the plants need to be cleaned before they are sent to market.

Refrigerated storage

This is an expensive method because it requires appropriate facilities, but it allows easy access to the accumulated goods in winter, depending on market needs. Harvesting of plants is carried out before the onset of frosts. Both the collection and preparation of leek for storage and their insertion into the refrigeration chamber should take place on the same day. One of the conditions for proper storage of leek is their rapid cooling and protection against wilting. Leek can be stored in universal boxes, in which the plants are laid flat, and in special boxes for leek and pallet boxes, in which the plants are positioned vertically or arranged horizontally. Packages containing plant material should be placed in the chamber in accordance with the storage recommendations, i.e., leaving free spaces between the rows of packages, between the walls and the rows of packages, and under the ceiling. This is to ensure free access of cold air to all packages and maintain a uniform temperature throughout the refrigeration chamber. If there are problems with maintaining high humidity, air humidifiers should be used. Individual boxes or entire columns can be covered with perforated polyethylene film. It is necessary to protect leek from wilting, because with natural losses exceeding 7 %, it becomes unsuitable for trade. Temperature fluctuations during storage are very dangerous, as they may lead to the condensation of water vapour in the pores, which promotes the rotting of plants.
Maintaining high-quality pores during storage is facilitated by a controlled atmosphere. With 1-2 % O_2 and 5-10% CO_2 in the atmosphere, the leaves retain their green colour for longer and the plants look fresh.

8.3. Preparing for trade

Regardless of how the leek is stored, plants intended for trade should be whole, fresh, clean, healthy, firm, with no dried or mechanically damaged parts. At the end of the storage period, the leek is cleaned and placed in boxes, bundled into bunches of several pieces, or packed into individual packages. When storing leek at a temperature of -1.5°C, it is necessary to ensure that, after removal from the cold store, the plants are gradually thawed at a temperature of up to 5°C. Care should also be taken to maintain appropriate conditions during trade, namely, the leek should be protected against wilting and kept at a low temperature.

XIX. HYGIENE AND HEALTH PRINCIPLES

Dr Maria Grzegorzewska

During harvest and the preparation of crops produced under integrated plant production for sale, the producer ensures that the following health and hygiene rules are followed.

9.1. Personal hygiene of employees

1. Employees harvesting fruit and preparing it for sale shall:

a. not be a carrier of or have food-borne disease;
b. possess an appropriate health record book;
c. maintain personal cleanliness, obey the rules of hygiene, and in particular regularly wash hands during work;
d. wear clean clothes and, if necessary, protective clothing;
e. cover cuts and abrasions with a waterproof dressing.
f. tie or tighten long hair and, in justified cases, wear headgear that completely covers the hair;

2. A plant producer shall provide employees harvesting and preparing crops for sales with:
a. unlimited access to washbasins and toilets, cleaning products, disposable towels or hand dryers, etc.;
b. hygiene training.

9.2. Hygiene requirements for crops prepared for sale.

A plant producer shall take appropriate measures to ensure that:
a. the use of clean water or water of the class intended for consumption to wash agricultural produce as required;
b. the protection of crops during and after harvest against physical, chemical, and biological contamination.

9.3. Requirements of hygiene in the integrated plant production system with regard to packaging, means of transport and locations for preparing agricultural produce for sale

Growers in an Integrated Crop Production system will take appropriate measures to ensure that:
a. premises (including equipment), means of transport, and packaging are maintained in clean condition;
b. farm and domestic animals have no access to the rooms, vehicles and packaging;
c. order in driveways and around buildings where the goods are stored and prepared for trade is maintained;
d. harmful organisms (pests and organisms dangerous to humans), which may lead to contamination or pose a threat to human health, e.g. mycotoxins, are eliminated;
e. waste and hazardous substances are not stored with crops prepared for sale.

X. GENERAL RULES FOR 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 a fundamental system for 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 and on their surface. 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.

A certificate issued at the request of the grower attests that integrated plant production principles are followed.

The certificate which certifies the application of integrated plant production is issued if the crop producer meets the following requirements:

- has completed training in integrated crop production and has a certificate of completion of this training, subject to Article 64(4), (5), (7) and (8) of the Act on plant protection products,
- 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 based on 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.

XI. 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.

Model notebooks are included in the Annex to 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).

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 application 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 rotation 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 – variety, category, degree of qualification, quantity, and proof of purchase (invoice), official label combined with plant passport, or marketing label and plant passport.

Sowing (...) — in the table, record the quantity of seed used in individual fields. The dates of the activities carried out should also be recorded. Information on soil testing/assessment for existing pests that exclude the field from IP cultivation should be confirmed by ticking the relevant boxes (□).

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. The field code, the type or scope of testing and the number and date of the report should be entered in the ‘Soil and plant analysis’ table. 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 system of integrated plant production 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 agrophages 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.

XIII. LITERATURE

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XIII. CONTROL LISTS FOR INTEGRATED PRODUCTION

LIST OF MANDATORY ACTIVITIES AND PROCEDURES IN THE INTEGRATED PRODUCTION SYSTEM OF LEEK

Mandatory requirements (100 % compliance, i.e. 15 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Use of crop rotation – not cultivating leek after allium vegetables (onions, garlic, leek, Welsh onions, chives) in the same field more frequently than every 4 years (see chapter III, 3.1); Chapter VI. 6.2)	❑/❑	
2.	Determination of the soil reaction in the year preceding leek cultivation, confirmed by the results of the analysis, and liming if necessary. (The cultivation of leek is also permitted if the determination of the soil reaction is carried out in the year of commencement of cultivation, provided that the pH of the soil is within the optimum range for leek) (see chapter III, 3.5).	❑/❑	
3.	Analysis of soil abundance before the start of leek cultivation, determination of fertilising needs (confirmed by the results of soil analysis) and application of optimal fertilisation (see chapter III, 3.5).	❑/❑	
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 VI, 6.1. a, b, c).	❑/❑	
5.	Inspections of leek plantation, at least once a week, for the presence of the following diseases: leek rust, alternaria blight of leek, and sclerotinia rot (see chapter VI, 6.1. c).	❑/❑	
6.	Interventional control of leek rust and leek alternariosis only after the risk of infection is determined on the basis of an analysis of weather conditions (see chapter VI, 6.1. c).	❑/❑	
7.	Alternating the use of plant protection products with different mechanisms of action to prevent pest resistance to pesticides (if possible) (see chapter IV).	❑/❑	
8.	Inclusion of non-chemical agents in the programme for the protection of plants against pests and pathogens[1] (at least one of the treatments should be performed with such a preparation) (see chapter VI, 6.1. c, ch., VII, 7.4).	❑/❑	
9.	Removal and destruction of plants with symptoms of infestation by pathogens and pests to an extent that	❑/❑	

	prevents further growth of plants (deformations, signs of rotting) (see chapter VI, 6.1. a, b, c).		
10.	Monitoring of the flight of turnip moth from May to September using pheromone traps (2 pcs/ha) and their inspection once a week (see chapter VII. 7.1)	❑/❑	
11.	Monitoring the occurrence of tobacco thrips from the beginning of June to the end of August using blue or yellow sticky boards (4 units/ha). (see chapter VII. 7.1)	❑/❑	
12.	Inspections of the leek plantation should be conducted at least once a week for the presence of plants damaged by onion leaf miner, tobacco thrips, leek miner, and cutworms (see chapter VII. 7.1)	❑/❑	
13.	Placement of "houses" for mason bee or mounds for bumblebees in the amount of at least 1 per 5 ha, and in the case of larger plantations – several units (see chapter VII, 7.3).	❑/❑	
14.	Identifying weed species in the field intended for leek cultivation (in the year preceding the cultivation) and entering their names in the Integrated Production Notebook (see chapter V, 5.1).	❑/❑	
15.	Mowing uncultivated areas belonging to the same farm around the plantations (e.g. field margins, ditches, roads) at least 2 times a year (end of May/beginning of June and end of July/beginning of August) to prevent weeds from releasing seeds (see chapter V, 5.2).	❑/❑	

[1]Where such plant protection products are authorised

Attention
The fulfilment of all requirements in the list of mandatory operations and treatments in the integrated production system shall be documented in the Integrated Crop Production Notebook.

CHECKLIST FOR FIELD VEGETABLE CROPS

Basic requirements (100% compliance, i.e. 29 points)			
Item	**Checkpoints**	**YES/NO**	**Comment**
1.	Does the producer produce and protect the crops according to detailed methodologies approved by the Chief Inspector?	□/□	
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 Crop 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 deal with 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 procedures using plant protection products carried out only by persons having an up-to-date, as of the date of such procedures, certificate on the completion of training in the scope of the application of plant protection products or advisory on plant protection products, or integrated plant production, or any other document confirming the right to apply plant protection products?	□/□	
12.	Are the applied plant protection products authorized for IP and use in a given crop or 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 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 and protection of beneficial organisms ensured?	□/□	
	Total points		

Additional requirements for open-field vegetable crops (at least 50 % compliance i.e. 11 points)

Item	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.	Do the seeds or seedlings used meet the requirements for production and quality?	□/□	
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 water of drinking water class 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 (min. implementation 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		