MAIN INSPECTORATE OF PLANT HEALTH AND SEED INSPECTION

Draft

METHODOLOGY
FOR INTEGRATED PRODUCTION OF SAVOY CABBAGE

Approved

by virtue of Article 57(2)(2) of the Plant Protection Products Act of 8 March 2013

(consolidated text: Journal of Laws of 2024, item 630)

by

the Main Inspector of Plant Health and Seed Inspection

Warsaw, November 2024

INTEGRATED PRODUCTION
OFFICIALLY CONTROLLED

Approved by
~~/signed electronically/~~

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I. INTRODUCTION

Integrated Plant Production (IP) is a modern system that makes sustainable use of technical and biological progress in cultivation, plant protection and fertilisation and pays particular attention to the protection of the environment and human health. 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. They concern in particular the priority in the use of non-chemical methods, supplemented by chemical methods, which are used when the expected economic losses caused by pests are higher than the costs of treatments.

Among others, application of IP is a guarantee of production of high-quality food, not exceeding permissible residues of harmful substances, less expenditure on production (fertilising based on the actual demand of plants for nutrients), and the rational use of plant protection products. Moreover, it helps reduce environmental pollution with chemical plant protection products, enhances biodiversity of agrocenoses and raises awareness among consumers and fruit and vegetable producers.

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 of Agriculture and Rural Development of 24 June 2013 on documenting activities related to integrated plant production (consolidated text: Journal of Laws of 2023, item 2501) and Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on the qualification of persons carrying out checks on compliance with the requirements of integrated plant production and the model certificate certifying the use of integrated plant production (consolidated text: Journal of Laws of 2023, item 1397) 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 methodology of Integrated Production of Savoy cabbage covers all issues related to cultivation, fertilisation, site selection, crop rotation, soil preparation, sowing, irrigation, agrotechnical treatments, variety selection as well as protection against pests 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 Savoy cabbage production system.

This methodology has been developed based on the results of research conducted at the Institute of Horticulture – National Research Institute and the latest data from the literature, in accordance with the requirements of integrated pest management and the guidelines of the International Organization for Biological and Integrated Control of Noxious Animals and Plants (IOBC), as well as the International Society for Horticultural Science.

II. AGROTECHNICS IN INTEGRATED PRODUCTION OF SAVOY CABBAGE

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II.1. Origin of the species

Wild cabbage *Brassica oleracea var. silvestris* L. is considered to be the initial form of Brassica vegetables belonging to the species *Brassica oleracea*, which occurs on the European part of the Atlantic coast and the Mediterranean Sea. The first descriptions of Savoy cabbage date back to the 16th century. This plant differs significantly from other cabbages because its leaves are wrinkled and covered with dark green, blister-like protrusions. Compared to white head cabbage, it forms smaller and lighter heads. Savoy cabbage is a biennial plant, which in the first year develops a head that is a terminal bud, while after a period of dormancy conditioned by a drop in temperature to 1-3°C (for at least 4 weeks), enters generative development.

This plant has a taproot, which also grows strongly to the sides (especially in the case of damage to the main root). The cabbage stem is called the stump, and in the first year of growth, it is thickened and shortened. The leaves are very densely set on the stump, and dormant buds are located in their axils. The first leaves begin to form a rosette, inside which more leaves grow, strongly overlapping each other. In the final phase, the initially open top bud is closed. The leaves growing inside the head slowly increase its size and hardness. The leaves are set on short stalks or are completely devoid of them. In the second year of vegetation, leafy inflorescence shoots are formed. The fruit is a cracking, oblong-oval pod reaching a length of several to a dozen centimetres. Inside it, there are seeds with a shape similar to spherical and a dark brown colour.

Savoy cabbage, compared to white head cabbage, contains more vitamin A, nitrogen compounds, and dry matter. It is also considered by many consumers to be tastier than white cabbage. Despite its advantages, it is a vegetable that is quite uncommon in our country.

II.2. Climate and soil requirements

Savoy cabbage has similar climatic and soil requirements to white cabbage. However, it is slightly more resistant to prolonged low temperatures and less sensitive to drought. Compared to white cabbage, it is also characterized by slightly lower soil requirements. The optimal temperature for the growth and development of Savoy cabbage ranges from 15-20°C, while the minimum is 5°C. Disorders in head formation occur at temperatures above 25°C, and temperatures above 35°C inhibit its growth and development. The seedling, which in the final production process was tempered, is able to withstand temperature drops to -6°C, and heads are ready for harvest to -9°C. In the case of some late varieties of Savoy cabbage, the grown heads can withstand temperatures up to -15°C. Savoy cabbage, due to the large amount of biomass produced, has a high demand for water, especially during the period of setting and growing heads. However, even just after planting seedlings in the field,

a water deficit can cause plant loss. Due to the high demand for nutrients, Savoy cabbage grows well and yields better on humus-rich soils abundant in the macronutrients necessary for its growth.

For the cultivation of Savoy cabbage, sites characterized by very heavy, cold, and wet soils, as well as sandy soils, should not be selected. The best soils for the cultivation of this plant are considered to be soils formed from loess, light clays, and strong loamy sands with a deep humus layer and regulated water-air relations. Savoy cabbage, for phytosanitary reasons (mainly due to clubroot), should not be grown in succession or after other plants of the Brassica family at intervals of less than 4 years. Due to the possibility of spreading beet cyst eelworm, its cultivation should also be avoided in beet and spinach fields.

II.3. Site and crop rotation

Due to the above-mentioned high water demand, the most favourable areas for the cultivation of Savoy cabbage are coastal and sub-mountain regions, which are characterized by heavy rainfall. An additional advantage is the proximity of water reservoirs or water intakes necessary for irrigation. For early varieties, it is recommended to locate plantations on lighter soils that heat up faster. It should also be noted that the site for growing this plant should not be shaded or located in a depression, which is conducive to the accumulation of cold air. A very important aspect in the selection of the site for the cultivation of Brassica vegetables is that it is free from clubroot. Savoy cabbage is often grown after plants of the Fabaceae family due to their ability to accumulate atmospheric nitrogen, as well as after tomatoes or root vegetables.

Table 1. Examples of plants recommended and not recommended for use as precursor crop for Savoy cabbage

Recommended plants	Not recommended plants
- Allioideae: leek, onion, garlic - Cucurbitaceae: melon, cucumber, pumpkin - Fabaceae: pea, bean, broad bean, vetch, field pea, lupin, clover, alfalfa - tomato, pepper - carrot, potato, celery, lettuce, chicory - cereals: wheat, triticale, rye, barley - phacelia, buckwheat	- Brassica: cabbage, broccoli, cauliflower, Brussels sprouts, kale, horseradish, radish, turnips, kohlrabi, spring and winter oilseed rape, turnip rape, mustard, oil radish, turnip - beet (red, sugar and fodder) - spinach - rhubarb

II.4. Soil cultivation

The site for growing Savoy cabbage should be prepared very carefully, especially in the case of cultivation from sowing directly into the ground. The method of preparing the site for this species of cabbage also depends on factors such as the type of soil, the date of cultivation, the date of departure from the field, and the type of precursor crop. In the case of cultivation after cereals, immediately after harvesting, it is best to carry out ploughing or discing and harrowing. In the interests of environmental protection, in order to reduce the

leaching of nutrients from the soil (N and P), it is worth cultivating catch crops for ploughing. This treatment also improves the balance of organic matter, which is usually negative when growing vegetables.

In autumn, especially on heavier soil types, it is recommended to carry out subsoiling, which deeply loosens the soil and facilitates its penetration by the root system. As for spring agrotechnical works, they are limited to leveling the field surface and destroying weeds with a harrow or light combined cultivator. In the case of the cultivation of Savoy cabbage after early harvested precursor crops, it is necessary to cover the plant residue by ploughing. During this process or shortly thereafter, the Campbell roller should be used, followed by harrowing. In accordance with the principles of integrated production, as few cultivation operations as possible should be carried out, but not fewer than necessary to properly prepare the site for the needs of a given species. This can be achieved by using combined cultivators, which significantly reduces the number of runs made by agricultural machinery, thereby preventing excessive soil compaction. Excessive compaction of the soil is a very undesirable phenomenon, as it limits its aeration and, during rains, leads to surface run-off. All cultivation procedures should be carried out in accordance with the Code of Good Agricultural Practice.

II.5. Selection of varieties

The seed variety depends on many factors, the most important of which are the cultivation period and the purpose of the crop. Having defined the above parameters, the choice can be significantly narrowed down. The different varieties differ from one another in terms of yield, taste, earliness, storage durability, suitability for processing, or resistance to pathogens. In the case of Savoy cabbage, depending on the variety, the heads may differ significantly in shape, colour, and compactness. This is directly due to the structure of the leaves, as these often differ in thickness, venation, or degree of wrinkling. An important criterion for the selection of a variety is also its resistance or tolerance to diseases and pests.

Varieties of Savoy cabbage, based on the length of the growing season, are divided into four main groups: early (55-80 days), medium early (80-110 days), medium late (110-130 days), and late (130-160 days). Early varieties are grown mainly for direct consumption. Production is carried out under various types of cover or in the field. The characteristics that should define a good variety of cabbage intended for spring cultivation are: a short growing season, low susceptibility to premature growth of inflorescence shoots, and high tolerance to temperature drops that may occur during the growing season.

It is desirable for medium-early and medium-late varieties to be able to keep mature plants in the field without compromising the quality of the heads, and for late varieties to be suitable for storage.

Information on varieties of Savoy cabbage can be found, among others, on the producers' websites and in the National Register of Varieties of Agricultural Plants - COBORU https://www.coboru.gov.pl/pl/kr/kr.

For the production of seedlings and for sowing, it is required to use seed material of at least the standard category.

II.6. Times and methods of cultivation

The earliest plantings of Savoy cabbage are carried out in foil tunnels. They fall in the first half of March. Depending on the cultivation period and the variety, Savoy cabbage can be planted in the ground from the beginning of March to around 15 July. The first dates for planting early varieties in open ground are in early April, while varieties intended for winter harvest, tolerant to significant temperature drops, are planted in the first half of July.

Table 2. Approximate times for sowing seeds, planting seedlings and harvesting Savoy cabbage grown in the field

Crop for harvest	Type of varieties	Sowing term	Planting term	Harvest period
Spring	Early	First half of II	From beginning to end of April	From late May to mid July
Summer	Medium-early	From early to late March	From late April to mid May	From mid July to late September
Autumn	Medium-late and late	From late March III to late April	From mid May to mid June	From late September to early November
Winter	Some medium late and late	From mid to late May	From early to late July	December to mid February

Savoy cabbage is grown both from direct sowing into the ground and from seedlings. In integrated production, it is recommended to grow from seedlings, where there are fewer problems with weeds and the yields obtained are more uniform. However, production from seedlings is more labour-intensive and requires greater financial outlays.

II.7. Production of seedlings

The production of seedlings can be carried out both in plant trays (less often in individual pots) and on the seedbed.

In the case of seedbed production, the choice of the right place is an important aspect. The seedbed should be located on fertile humus soil with a tendency to heat up quickly. The site should also be free from weeds and pathogens. As regards phytosanitary rules, as in the case of field crops, the seedbed should not be established in the same place more often than every 4 years. With favourable weather, sowing seeds on a seedbed in outdoor soil can be carried out from early April to May. For seedbeds located in unheated foil tunnels, seed sowing begins already in March. The production period lasts from 5 to 6 weeks. The doses and choice of fertilisers used should meet the requirements of integrated fertilisation, taking into account the nutrient richness of the soil and the requirements of the plants. If there is a choice, first use organic fertilisers (manure, compost), adjusting the dose to the requirements of the nitrogen program. Seeds can be sown manually or with a seed drill. The distance between the rows should be 10-15 cm, while the depth of sowing should be 1.5-2 cm. The size of the seedbed to provide seedlings for a field of 1 ha should be 100-150 m^2. Sowing such an area requires the use of 200 to 300 g of seeds.

Another way to produce seedlings is to use plant trays (trays with multiple cells). Peat substrates are used as substrates for filling plant trays, which are enriched with nutrients and deacidified. The substrate used for the production of seedlings must also not contain weed seeds or pathogens. It is possible to use both ready-made substrates and to make them on your own. Depending on the date of production, plant trays with different capacities of a single cell are used. In the case of early cabbage, plant trays with cells of 90 cm^3 are most often used. In the case of medium-early and medium-late crops, plant trays with a cell capacity of 25 to 53 cm^3 are used. Plant trays with a single cell size of 15 cm^3 may be used for growing for the late harvest. The optimum depth of seed sowing is from 8 to 10 mm. Plant trays with sown seeds should be set on racks that will isolate young plants from the ground, as well as reduce the risk of excessive flooding of the root system. The optimum temperature for seedlings prepared under cover is: 18-20°C (after sowing), 14-16°C (after emergence during the day), 10-12°C (after emergence at night). After the production of the 4th leaf, the temperature should not be lower than 12°C, as this could lead to vernalisation. The duration of seedling production is about 8 weeks for early cabbage, 5 to 6 weeks for medium early cabbage, and about 4 weeks for late cabbage. The seedling is planted in the field when it develops 4 to 6 leaves. At the end of the production period, a few days before planting, it should also be hardened.

II.8. Planting of seedlings

The spacing of planting seedlings of Savoy cabbage is determined by the date of its cultivation, the purpose of the crop, and the variety. It is planted in rows 45 or 67 cm apart. For integrated crops, it is recommended to plant seedlings in a belt-row system. Such a planting system makes it possible to enter the plantation with an agricultural tractor in order to carry out the necessary agrotechnical work, without the risk of damage to the plants. On a 135 or 150 cm wide bed, 3 rows of plants are planted 40 or 45 cm apart, respectively, and the distance between the extreme rows of beds is 55 or 60 cm (55×40×40 or 60×45×45 cm). The number of seedlings needed for a field with an area of 1 ha is 35,000-50,000. Often, immediately after planting, the plants are covered with polypropylene crop cover. This can speed up the harvest date by up to 3 weeks and additionally protects plants from pests such as cabbage flies or flea beetles. The crop cover is removed from the field 2 weeks before harvesting.

II.9. Cultivation by sowing

Cultivation by sowing is a cheaper alternative to the production of Savoy cabbage, but it does not provide as uniform a yield as cultivation from seedlings. Sowing is mainly used for medium-late and late harvest crops. The advantage of cabbage grown from sowing is its root system, which is stronger and longer compared to cabbage grown from seedlings. This is particularly important on plantations where it is impossible to carry out irrigation. Sowing seeds should be done in moist soil, preferably by the end of April. The depth of sowing should be from 1.5 to 2 cm. The optimal way of sowing is to use precision seed drills that

sow seeds at consistent intervals. Under favourable growing conditions, the spacing is the same as for planting seedlings. Better uniformity in planting is achieved by shortening the distance between seeds sown in a row. However, in this case, every second plant should be removed after full emergence. The spacing of the rows is similar to that for seedlings. Savoy cabbage germinates 4-5 days after sowing.

II.10. Soil pH

A very important parameter that is largely responsible for the effectiveness of fertilisation is the soil pH. In the case of Brassica vegetables, soil pH is also important for phytosanitary reasons, because too low a value of this parameter significantly increases the risk of the most dangerous disease, which is clubroot. The optimum pH value of the soil for the cultivation of Savoy cabbage is 6.5-7.5. Inadequate soil pH limits the biological properties of the soil (quantity and quality of microorganisms), which prevents plants from fully exploiting the production potential of the soil.

Liming should be carried out in the year preceding the cultivation of Savoy cabbage, immediately after the harvest of the precursor crop. The dose of lime is best determined on the basis of chemical analyses of the soil (pH and hydrolytic acidity). On soils low in magnesium, it is possible to use magnesium lime.

II.11. Nutritional requirements and fertiliser needs

Due to the large amount of biomass produced by Savoy cabbage, it has significant nutritional requirements, especially in terms of nitrogen and potassium. The amount of nutrients necessary for the proper growth and development of plants depends to a large extent on the length of the vegetation period of a particular variety. Varieties with a longer growing season will have a higher nutrient demand. Cabbage on average absorbs for the production of 1 T of yield: 3.5 kg N; 1.2 kg P_2O_5; 4 kg K_2O and 0.3 kg MgO.

Table 3. Optimal content of basic macronutrients in the soil (mg/dm^3) for the cultivation of Savoy cabbage

N	P	K	Mg	Ca
105-120	50-70	160-190	55-65	700-1200

In integrated production, fertilisation should be applied based on the results of soil analysis, which is performed in specialised chemical laboratories or chemical-agricultural stations. Determination of the content of assimilable forms of elements in the soil, necessary for the proper growth and development of plants, is the basis for rational fertilisation. The lower values of the ranges given in Table 3 refer to optimal nutrient content on light soils, and the higher values on heavy soils.

II.12. Organic fertilisation

Due to the high nutritional requirements of Savoy cabbage, it is most often grown in the first year after manure. The maximum dose of organic fertilisers specified by law (under the Regulation of the Council of Ministers (Journal of Laws of 2020, item 243), effective from 15 February 2020) is 170 kg N/ha per year. In addition to manure, other types of organic and organic-rich fertilisers (e.g. compost, used substrates, improvers, etc.) can also be used. The use of fertilisers of this type allows for the reduction of mineral fertilisation doses. In addition, it increases the content of organic matter in the soil, which positively affects its structure, water capacity, and the development of the soil microbiome. For Savoy cabbage, organic fertilisation is best applied in the autumn of the year preceding the crop. Instead of natural fertilisers, green fertilisers or shredded straw can also be used after harvesting cereals. For green fertilisers, it is worth growing Fabaceae plants such as vetch, field pea, lupins, as well as their mixtures. Phacelia and buckwheat are also valuable species.

II.13. Mineral fertilisation

In order to obtain a high yield of Savoy cabbage in integrated production, organic fertilisation should be supplemented with mineral fertilisation. In order to properly use mineral fertilisers, it is necessary to perform a chemical analysis of the soil to determine its parameters, including macronutrient content, salinity and pH. Only on the basis of these data is it possible to correctly select fertilisers and their doses. The application of fertilisation without prior soil analysis may, inter alia, lead to an over- or under-supply of nutrients. In both variants, the producer may suffer a loss resulting either from excessive fertiliser consumption or from a lower yield due to a deficit in one of the components.

The optimal range of macronutrients in soil for Savoy cabbage is shown in Table 3. Phosphorus and potassium fertilisers are applied in a single dose, approximately one week before sowing or planting seedlings. Nitrogen fertilisers for early varieties should be applied pre-vegetatively along with potassium and phosphorus fertilisers at 2/3 of the dose, with the remaining portion applied 2-3 weeks after planting.
For case of medium-late and late varieties, 1/2 dose of nitrogen is applied pre-vegetatively, while the remaining part is top-dressed in two stages: I — 2-3 weeks after planting or sowing seeds and II — 2-3 weeks later, but before the rows close. For pre-vegetation fertilisation, it is advisable to use nitrogen fertilisers in ammonium form, while for top dressing, nitrate forms are effective. When growing from sowing, it is important to mix fertilisers well with the soil. Both potassium sulphate and potassium salt can be used for potassium fertilisation (Savoy cabbage is not sensitive to chlorides). In cases where the boron content in the soil is unknown, to which Savoy cabbage is sensitive, it can be introduced, for example, during phosphorus fertilisation by choosing phosphorus fertilisers with the addition of this element. Multi-component fertilisers containing micronutrients are also very useful. Fertilisers of this type should be used especially on plantations where natural and organic fertilisers have not been applied. Phosphorus and potassium fertilisers are recommended to be used before winter ploughing due to the low ability of phosphorus to move deep into the soil profile. In

turn, fertilisers such as ammonium phosphate and compound fertilisers should be used in spring to minimise nitrogen losses. Maximum amounts of nitrogen from all sources (N in kg/ha) for yields obtained under conditions of regulated soil pH, balanced fertilisation with phosphorus and potassium (PK), should comply with the applicable provisions of the nitrate programme.

The uptake of nutrients by the root system may be slowed down due to unfavourable abiotic conditions, which include inappropriate soil reaction, low temperature, excessive soil moisture, or drought. In this case, it is worth using foliar feeding. Only authorised fertilisers should be used and in the doses indicated in the instructions for use. There are many different single and multi-component fertilisers available on the market that can be used for foliar feeding. Fertilisers in the form of chelates, which are better absorbed by plants, are very useful. Only fertilisers meeting the requirements of Regulation (EU) 2019/1009 and Regulation of the Ministry of Agriculture and Rural Development of 2019 should be used for mineral fertilisation in integrated crop production.

II.14. Care treatments

Care treatments should be carried out already at the seedling production stage, so that young plants are best adapted to the conditions that will prevail in the field. The basic requirement is to provide seedlings with optimal growth conditions such as access to light, adequate humidity (substrate and air), and optimum temperature at each stage of plant development. The most important care treatments in the field should include: weed control, irrigation, fertilisation, and protection against diseases and pests. The key period of water demand for Savoy cabbage is the period of head formation and growth. After the seedlings have taken root, it is not recommended to use irrigation for 3-4 weeks to allow the plants to root deeply. After this period, irrigation should be carried out so as to maintain optimal soil moisture for this species, which is 70-80 % of field water capacity (FWC). A single application rate of water should be 15-20 mm (on lighter soils) and 25-30 mm (on heavier soils).

III. INTEGRATED PROTECTION OF SAVOY CABBAGE AGAINST HARMFUL ORGANISMS

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Harmful organisms, i.e. pests (pathogens, weeds), are commonly found in crops, causing significant crop losses. Plant protection aims to prevent the reduction of yields and their quality, as well as the transmission and spread of pests in fields where they have not previously been present.

Integrated Pest Management, mandatory since 2014, is an important part of Integrated Plant Production. It uses natural biological and physiological mechanisms of plants, which are supported by the rational use of conventional, natural and biological plant protection products and knowledge of harmful organisms, in particular, their biology and harmfulness,

in order to determine optimal combating dates. It also takes advantage of naturally occurring beneficial organisms, including predators and parasites, which can be introduced. The essence of integrated plant protection is to obtain high yields of good quality, under optimal cultivation conditions, in a way that does not threaten the natural environment and human health, while maintaining the profitability of production.

In integrated plant protection, non-chemical methods are preferred: agro-technical and biological-mechanical, with the chemical method used to supplement them. Chemical pest protection should be carried out in accordance with the principles of Good Plant Protection Practice (GPP), which results, among others, from the relevant European Union directives (e.g. Directive 2009/128/EC of 21 October 2009) and the Plant Protection Products Act of 8 March 2013 (consolidated text: 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.

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, economic harmfulness thresholds, as well as signalling the appearance of pests or diseases and forecasting the occurrence of weeds.
- Products authorised for use in the Integrated Plant Production system should be used, in particular those with a short withdrawal period, which remain in the soil for a short time, decompose rapidly and have the least negative impact on the crop, soil and beneficial organisms.
- Always use agents authorised for use in the cultivation of the species and intended to control the specified pest, and comply with the recommended doses, timing, and method of use, as indicated on the label attached to the packaging of each agent. Prior to treatment, the producer is obliged to familiarise themselves with the label and instructions for the product to be used.
- **In the first instance, biological agents based on bacteria, fungi, or viruses and plant extracts should be selected. At least one plant protection treatment with a biological or biotechnical product shall be carried out during the growing season.**
- 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.
- Treatments with plant protection products should be carried out at the optimal temperature, air humidity, and wind strength, in such a way as to maximize their biological activity while reducing doses and limiting their use.

- The use of plant protection products should be reduced, inter alia, by precise use only in places of infestation with harmful organisms, the addition of adjuvants to the usable liquid, the use of split doses, and adaptation of doses to the development phases of the crop and weeds and soil conditions.
- The increase in the presence of agrophages, especially in large plantations, may be distributed unevenly, so the treatment may sometimes only be performed in the agrophage presence area, on peripheries or on selected parts of the field. In addition, in some years some of the agrophages do not occur or appear at an intensity that does not require control.
- One can use field mapping with modern methods (aerial or drone photos) to determine the symptoms of damage to cabbage, e.g. by pests or diseases, the distribution of weeds on the plantation, and to perform treatments only where necessary.
- Plant protection products differ from one another in terms of their period of activity and persistence in the soil and the environment. This should be taken into account in the planning of subsequent plants cultivated both after the full cultivation period and in the event of an earlier liquidation of the plantation, as a result of winter damage, destruction of plants by diseases or pests and others.
- **Agents with different mechanisms of action should be used to prevent pests from becoming resistant to the active substances they contain.** The alternating application of products results from the need to preserve biodiversity and protect the environment.
- The effects of plant protection products on harmful organisms and arable crops depend on the occurring pests, the cultivated plant species, as well as their developmental phases, soil and climatic conditions.
- Herbicides generally work more effectively the higher the temperature, while some insecticides may not work as well or cause damage to the crops being sprayed. It is recommended to spray the plantations during rain and windless weather when the air temperature is 10-20°C. If it is higher, treatments should be carried out early in the morning (when the crops are in full turgor) or in the afternoon.
- Chemical treatments should be performed with sprayers ensuring accurate coverage of the sprayed surface with drops of the spray liquid. Herbicides should be applied by means of sprayers equipped with low-pressure, flat nozzle sprayers, while vortex sprayers can be used for fungicides, insecticides and other agents.
- The spray liquid should be prepared in the amount necessary to spray the planned surface, preferably immediately before the treatment. In the event of 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).
- The sprayer, after the treatment, should be thoroughly washed in a place adapted for this purpose (biobed), preferably with special agents designed for this purpose, made on the basis of phosphates or sodium hypochlorite.
- Empty packages must be rinsed three times with water and the rinsing water poured into the spray tank.
- Treatments with plant protection products should only be carried out by persons trained by entities registered by the Provincial Plant Health and Seed Inspectorate. During the preparation of measures and the performance of treatments, it is necessary to comply with health and safety regulations and use appropriate protective clothing.
- Prior to the use of the product, all interested parties who may be exposed to the spraying of the liquid and who have requested such information should be informed of the above.

Current lists of agents registered to combat particular phytophagous pests in vegetable crops can be found in vegetable protection programmes published on the website of the Institute of Horticulture https://www.inhort.pl/serwis-ochrony-roslin/ochrona-roslin-rosliny-warzywne/, in trade journals or on the website of the Ministry of Agriculture and Rural Development at https://www.gov.pl/web/rolnictwo/ochrona-roslin**.**

List of plant protection products authorised for IP is available on the website of the Institute of Horticulture — NRI at https://www.inhort.pl/rosliny-warzywne-wykaz-srodkow/. In addition, information on plant protection products for integrated production is published in the Online Pest Warning System at https://www.agrofagi.com.pl/137,wykaz-srodkow-ochrony-roslin-do-integrowanej-produkcji-w-uprawach-warzywnych.

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:

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

III.1. Prevention in the reduction of harmful organisms in Savoy cabbage

The technology of growing Savoy cabbage includes a number of consecutive cultivation and care treatments that affect harmful organisms to varying degrees. The negative effects of pests on spinach plantations can be limited by providing appropriate conditions for growth and development of the crop, strengthening its defence mechanisms, increasing its resistance to pathogens, facilitating competition with weeds, and also by increasing the population of beneficial organisms. Prevention, which plays a very important role in counteracting all harmful organisms, includes elements such as: proper crop rotation, careful soil cultivation, selection of varieties adapted to soil and climatic conditions, fertilisation according to the plant's nutritional requirements and soil fertility, proper sowing dates, appropriate plant density, irrigation during periods of scarcity and high water demand, as well as careful plant care during the growing season.

Preventing the occurrence and spread of harmful organisms in the cultivation of Savoy cabbage involves the application of phytosanitary hygiene measures, which include:

- Careful harvesting of the precursor crop, which prevents seeds and weeds from being left in the field, as well as plant vegetative organs (e.g. roots, tubers). Buried weed seeds are a source of increased weed infestation of a field, while the seeds of certain cultivated plants may pose a problem in successive crops, e.g. self-seeding rape.
- Removal from the field of residues from the harvest of vegetables infected by diseases of fungal, bacterial, and viral origin. This prevents the perpetrators of diseases from multiplying in the soil,
- Quick and accurate covering of vegetable harvest residues, after the harvest of the precursor crop, which accelerates their decomposition by soil microorganisms. Plant residue can be a wintering place for many agents of diseases or pests, e.g. cutworms.
- Avoiding the use of poorly fermented manure, which may contain seeds of germinating weeds and various plant pathogens. Fertilising the field with manure usually results in an increase in weeds, as not all weed seeds are destroyed in the digestive tract of animals (e.g. white goosefoot, red-root pigweed, common chickweed, couch grass) or do not die during fermentation.
- Thorough covering of manure during ploughing — poorly covered manure attracts flies. Compared to the spring term, manure used in autumn weeds the field to a lesser extent, as weeds are destroyed mechanically during autumn or spring cultivation, and in addition, some of the weed seedlings die during winter.
- Use of compost and compost soil free from diseases, pests and weed seeds. The compost pile may be covered to prevent the laying of eggs by pests (e.g. crane flies, daddy-long-legs, beetles), and the production of seeds by weeds present on the pile must not be allowed.
- Production of seedlings in substrates free from harmful organisms. It is best to use ready-made substrates, prepared by professional companies. If self-produced substrates are

used, they should be thermally or chemically decontaminated, and their pH and nutrient content should be determined. To control the presence of soil pests, soil intended for seedling production should be sifted.

- For sowing seeds into pots or into the ground, seed material of at least standard quality should be used. Weeds should be removed manually during the seedling production period.
- Many diseases are transmitted onto fields together with Savoy cabbage seedlings, e.g. clubroot, dry rot, black bacterial spots, viruses, as well as some pests: cabbage flies, gall-making weevil, and aphids, which is why it is necessary to verify the quality of plants intended for planting and remove those which carry the perpetrators of damage;
- Periodic cleaning and removal of plant residues from vehicles, machinery and tools used for the production of seedlings and plant cultivation and care, as they are the main causes of the transfer of harmful organisms (e.g. nematodes, weed seeds, viruses).
- Preventing weed seeds from entering plantations from neighbouring areas and preventing weeds from blooming and releasing seeds on the margins, slopes, and shoulders. This is particularly important for those species whose seeds can be easily carried by wind or animals. Weeds can attract pests that inhabit Savoy cabbage, and their nectar is a source of food, while weed seeds contribute to increased weed infestation of the field in subsequent years.
- Systematic observations of Savoy cabbage plantations, identification of harmful organisms, and determination of their severity and area of occurrence.

IV. WEEDS

Dr Zbigniew Anyszka, *Dr Joanna Golian*, *Agata Szymczak*, *MSc Eng*.

IV.1. Occurrence and harmfulness of weeds to Savoy cabbage

In the cultivation of Savoy cabbage, weeds are common, regardless of habitat conditions. The sensitivity of cabbage to weeding depends, among other things, on the method and timing of cultivation, plant density, and environmental factors. The highest losses are caused by weeds which emerge during the emergence/planting period until the inter-rows become covered by leaves, in the so-called critical period of competition. The threat to cabbage increases during drought, as weeds take up significant amounts of water and shade the soil, which contributes to lowering its temperature and subsequent yield.

Cabbage, grown from seedlings, belongs to species moderately sensitive to weeds, due to the rapid growth in the initial growing season and good coverage of the rows by the leaves, while when grown from sowing, it is definitely more sensitive than when grown from seedlings. This is due to the much longer period of weed competition, which lasts from emergence, which is why it is much more often grown from seedlings.

The planting date for Savoy cabbage seedlings starts at the beginning of April and lasts until mid July, so weeding varies from one cultivation period to another. In April, weeds appear that germinate at low temperatures, followed by thermophilic species. The intended

use of the crop and the associated length of the growing season are also important. Cabbages grown for the late autumn and even winter harvest require more intensive weeding compared to those grown under cover for the early harvest, as well as early and medium-late varieties. Failure to weed the Savoy cabbage can significantly reduce the yield and deteriorate the quality of the heads.

Dicot and monocot weeds may be present in Savoy cabbage crops, both annual and perennial, and the dynamics of their appearance and species composition depend mainly on the seed stock in the soil, habitat, and atmospheric conditions. 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). On cabbage plantations cultivated since April, weed species germinating at low temperatures (daily average 2-5°C) appear, such as: white goosefoot, field mustard, common chickweed, shepherd's purse, annual nettle, field pennycress, redshank, buck-bindweed, mayweed, wild radish, common groundsel, red dead-nettle. In the later period of vegetation, in addition to the listed species, there are often: potato weed, red-root pigweed, cockspur grass, and sometimes black nightshade. Of monocot weeds, in addition to cockspur grass, the most common are couch grass, green foxtail, wild oat. Species of the Brassica family are particularly dangerous, as they are difficult to effectively combat with the herbicides recommended for Savoy cabbage. In crops under shelter, in addition to mass-emerging species with low thermal requirements, thermophilic species may appear: potato weed, cockspur grass.

High nitrogen fertilisation of cabbage crops promotes the intensive development of white goosefoot, potato weed, annual nettle, red-root pigweed, or common chickweed, which are classified as nitrophilic weeds.

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, and are a major component of secondary weed infestation. These include: white goosefoot, potato weed, field mustard, field pennycress, field pansy, common stork's-bill, etc. Secondary weeding is much less harmful to Savoy cabbage than primary weeding, but it worsens the phytosanitary conditions in the crop and makes it difficult to carry out treatments with plant protection products, contributes to delaying the harvest date, deteriorates the quality of the heads and reduces their nutritional value, makes harvesting difficult, prolongs the working time of machines, reduces their precision and work efficiency, deteriorates the economic efficiency of cabbage production, and can also affect storage. It is particularly important to prevent weeds from releasing seeds, as they can remain in the soil for a long time and increase weed infestation in subsequent years. Secondary weeding increases when plant density decreases and the amount of free space increases due to cabbage plant 'losses'. The harmfulness of major weed species to Savoy cabbage is shown in Table 4.

Table 4. Harmfulness of major weed species in Savoy cabbage crops

Species – English and Latin name	Harmfulness
1. Dicotyledonous weeds	
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.)	**+**
Dead-nettles (*Lamium* spp.)	**++**
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.)	**++**
Foxtails (*Setaria* ssp.)	**+**

(+++**)** very high harmfulness; (++**)** high harmfulness; (+**)** low harmfulness or weed of local importance

NOTE! Proper protection against weeds requires knowing weed species and methods of their control. **The responsibility of every IP producer** is **to identify the weed species present in the field** intended for the cultivation of Savoy cabbage and to record their names in the integrated production notebook. Observations should be carried out in the year preceding the cultivation of Savoy cabbage. For the proper identification of weed species, the Integrated Protection Methodology of Savoy cabbage 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/serwis-ochrony-roslin/metodyki-rosliny-warzywne/. In order to facilitate protection in follow-on crops, weed species should also be identified during the cultivation of Savoy cabbage and their names recorded in the IP notebook.

IV.2. Prevention and combating of weeds using agronomic methods

In the integrated protection of Savoy cabbage against weeds, agrotechnical methods and, above all, mechanical treatments are of great importance. Treatments carried out in

the period preceding the planting of cabbage seedlings are used to create the appropriate soil structure, destroy weed seedlings, and reduce the seed content in the soil. Mechanical treatments performed during the cultivation of cabbage make it possible to keep weeds at a very low level, without the use of herbicides.

- Savoy cabbage plantations are best established on fields maintained in good condition, with little weed presence. Fields infested with perennial weeds (e.g. field horsetail, field bindweed, woodland radish, etc.) should be avoided. This is particularly important for cabbage grown under non-woven fabric or foil, as the early planting date of seedlings does not allow for limiting weeds through mechanical treatments. Careful selection of the field for cultivation is important, despite the fact that cabbage is moderately sensitive to weeds, and weeds can be destroyed mechanically.

- In the cultivation of cabbage for early harvest, covered with non-woven fabric or perforated film, intensively growing weeds should be removed after removing the covers or uncovering the beds on one side. After weeding, the plants should be covered again. After removing the covers (about 5-6 weeks from planting), weeding should be repeated.

- In the cultivation of late-planted cabbage, a relatively long period from the thawing of the soil to the time of planting should be used to destroy weeds with mechanical treatments. Spring treatments should be based on drag harrowing, soil disturbance, and harrowing, as these treatments reduce field weed growth.

- Cabbage, like other vegetable species of the Brassica family, should not be grown on the same field more often than every 4 years, due to the possibility of many pathogens.

- During a drought, prior to planting cabbage seedlings, it is necessary to conduct only the necessary cultivation procedures so as not to pulverise the soil or worsen its structure; A good way to reduce weeds is to irrigate the field, which stimulates weeds to germinate, and after about 5-7 days, to carry out harrowing or using a combined cultivator, to destroy weed seedlings and prepare the soil for planting.

- The seedlings of Savoy cabbage should be planted in well-cultivated soil, to the same depth. Adequate density of plants in the field, corresponding to the requirements of the cultivated variety and site, and the absence of ‘gaps’, reduces the risk of secondary weed growth. In the few days following the planting of seedlings, the missing cabbage plants should be replenished to prevent weeds from occupying empty spaces. In the cultivation from sowing, after emergence, in vacant spots, additional cabbage plants can be planted.

- In the precursor crops of Savoy cabbage, particular attention should be paid to the control of weeds of the Brassica family (e.g. shepherd’s purse, field pennycress, field mustard, wild radish), as these plants are infested by the same diseases and pests as cabbage.

- Weeds must not be allowed to flower and produce seeds since a large supply of viable seeds in soil contributes to greater weed infestation in subsequent years, and flowering weeds attract pests.

- The use of the phenomenon of allelopathy to reduce the occurrence of weeds. Potential infestation with certain weed species significantly reduces the mixtures grown in the main crop as catch crops or cover crops (e.g. mustard, winter rye, blue phacelia, oil radish, buckwheat, green fertilisers). Successor crops should be maintained until flowering and no seeds should be allowed to be released by the cultivated plants.

- Predicting the occurrence of weed species and their severity, based on observations conducted in precursor crops, in the field intended for cabbage cultivation, will facilitate proper weeding.

- Avoiding the cultivation of Savoy cabbage after plants have been treated with long-acting herbicides, as their residues can cause damage to Savoy cabbage plants.

NOTE! In order to prevent the production of seeds by weeds, as well as the transfer of weed seeds or their vegetative organs from neighbouring areas to the Savoy cabbage plantation, **it is obligatory to mow uncultivated land around the plantation belonging to the same holding** (e.g. field margins, ditches, roads), at least twice a year, preferably at the end of May/beginning of June and at the end of July/beginning of August.

IV.3. Mechanical methods of weed control

Mechanical treatments, performed before sowing or planting cabbage seedlings, are used to create the appropriate soil structure, destroy weed seedlings, and reduce the stock of their seeds in the soil. For mechanical weed control during cultivation, passive tools with angular knives and duckfoot shares are usually used, most often combined with inter-row string rollers. Such weeders can only be used for inter-row weeding. New technical solutions, currently used in the development of tools, offer broader possibilities for weed destruction. They can be used between the rows, close to the crop, and also to destroy weeds in the plant rows. Such tools include brush weeders, finger weeders, or brush-finger weeders as well as torsion weeders. Modern and functional weeders usually consist of different weeding elements. Such weeders on cabbage plantations from seedlings can be used after weed emergence, when they have 2-4 true leaves, and in cultivation from sowing after emergence, in the phase of 2-3 cabbage leaves. Until then, from emergence, weeders can be used to destroy weeds between the rows. The rules for mechanical treatments in the cultivation of Savoy cabbage are as follows:

- The spacing of the cabbage rows should be adapted to the track width of the tractor and the tools with which mechanical treatments will be carried out.

- The manual and mechanical weeding may be performed after the appearance of weeds, preferably after rainfall or irrigation, once the soil has dried;

- Mechanical treatments in the cultivation of cabbage can be performed from planting seedlings until the inter-rows are covered by cabbage leaves, and with slight weeding, they can be omitted, as they accelerate germination and weed emergence. The first treatment should be performed after the appearance of weed seedlings (preferably in the cotyledon phase and the first pairs of leaves), and subsequent treatments depending on the rate of regrowth of weeds. In sowing cultivation, mechanical treatments can be started after the emergence of cabbage, when rows of plants are clearly visible. After covering the inter-rows with cabbage leaves, weeds must be removed manually only.

- The number of mechanical treatments depends on the dynamics of weed appearance and weather conditions. In early and medium-early varieties, there is usually a need for 1-2 treatments, and under optimal growing conditions this number may be limited. In the cultivation of late cabbage, it is recommended to perform 2-4 treatments, supplemented with 2-3 manual weedings, and with small weed infestation, 1-2 mechanical treatments supplemented with manual weeding may be enough. The number of treatments can be reduced in conditions conducive to the rapid growth of cabbage and in fields with low weed infestation.

- 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. Treatments performed too deeply are energy-intensive, can damage the cabbage root system, and move weed seeds capable of germination to the upper layer of the soil.

- Once herbicides are applied, mechanical and manual procedures should be performed when weeds are not destroyed effectively, and it is usually necessary to perform 1 procedure. The amount of work necessary in such pest control is much lower than in the case of cultivations without the use of herbicides.

IV.4. Chemical protection of Savoy cabbage against weeds

The integrated protection of Savoy cabbage against weeds should be based on proper prevention, compliance with agrotechnical recommendations, and the use of non-chemical methods, with herbicides being used only when other methods cannot effectively control weeds. Proper use of herbicides should take into account the choice of the appropriate agent and its dose, depending on the condition and degree of weed infestation, the timing of the procedure, and environmental conditions. The system of chemical protection of Savoy cabbage against weeds should be based on soil herbicides, applied before or after planting the seedlings, and foliar treatments should be carried out after planting the seedlings, based on the actual threat posed to the crop by the weeds. Soil herbicides protect the field from the emergence of weeds after planting seedlings, but under optimal soil and climatic conditions and the occurrence of weeds sensitive to the agents used, one treatment with such a measure may sometimes be enough to keep the plantation clean until the inter-rows are covered by cabbage leaves. Low soil moisture or drought occurring during and after

treatment can significantly weaken the effect of soil herbicides, in which case the weeds are not sufficiently effectively destroyed and there is a need to use foliar herbicides. Delaying the sowing date can also affect the drying of the soil and the effectiveness of herbicides.

HERBICIDES SHOULD BE USED IN LINE WITH THE CURRENTLY APPLICABLE RECOMMENDATIONS.
Detailed information on agro-technical requirements (seed depth, soil moisture), selection of the correct technique, and parameters of the treatment (quantity of water, working pressure, drop size) is included on the label of the plant protection product

IV.5. Rules for the selection and use of herbicides in Savoy cabbage

The selection of herbicides and their doses for weeding Savoy cabbage depends on the state of weed infestation in the field and the developmental stages of the weeds, and their effectiveness depends largely on the soil and climatic conditions. Adherence to recommendations for use, such as: dose, date of application, appropriate development phases of the crop and weeds and technical conditions of the treatment, among others, shall determine the safety of herbicide treatments. The rules for the selection of herbicides in the cultivation of Savoy cabbage are as follows:

- Herbicides registered and approved for weeding cabbage should be used, as recommended on the label of the product.
- In the cultivation of Savoy cabbage, it is not possible to control nuisance perennial weeds with herbicides, with the exception of couch grass, which is controlled by graminicides. In order to reduce the occurrence of perennial weeds, the principles of proper agrotechnics should be observed throughout the rotation.
- Soil-type herbicides are recommended to be applied on well-growing soil, with an even surface and adequate humidity. 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. On some soil types containing very large amounts of organic substances, e.g. peat soil, the effectiveness of soil-type herbicides is poor or there are no effects at all.
- Soil moisture has a significant impact on the action of soil herbicides; with low humidity, their effectiveness decreases. 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.
- Each agent has a specific optimal temperature range in which it works most effectively, without endangering crops. The optimum temperature for most herbicides is 10-20°C; for some, it is higher, e.g. graminicides should not be used at temperatures above 27°C.

During periods of high temperatures, treatments should be carried out in the afternoon or in the morning.

- Herbicides should be used during dry weather. The period between the treatment and precipitation varies for different products, and its length is often specified on product labels.
- The addition of adjuvants (auxiliary agents) to the spray solution of certain foliar herbicides enhances their effectiveness and reduces the consumption of the agent.
- The period when the herbicide is active and remains in the environment should be considered when planning crop rotation and follow-up crops.
- When using herbicides, especially after planting, attention should be paid to the length of withdrawal periods, mainly in varieties with a shorter growing season, in order to prevent the occurrence of residues of these agents in the consumption parts of Savoy cabbage.
- In the cultivation of cabbage, herbicides can be applied in strips, in rows of plants, and weeds in the inter-rows can be destroyed mechanically. Such a system is recommended for cabbage grown with a row spacing of 67.5-75 cm. Strip application of herbicides reduces their consumption.

IV.6. Plant succession after herbacide application

Herbicides vary in their duration of action and persistence in the soil, so this should be taken into account when planning follow-up crops.
The herbicide-use labels list the crop species that can be grown after the full crop season in which the product was applied. Most herbicides do not pose a threat to follow-on crops, but some products with a long soil retention period may cause symptoms of phytotoxicity on succeeding crops. If it is necessary to eliminate a plantation early (e.g. hail, flooding, destruction by disease or pests) where a herbicide has been applied, cultivate crops where the herbicide is recommended or species that are not sensitive to the active substance of the applied product. However, the cultivation of successor crops should be preceded by medium or deep ploughing. In order to prevent losses, it is important to familiarise yourself with information about the subsequent effects of herbicides, even before the start of cultivation.

V. DISEASES

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Choosing the right location for the establishment of a Savoy cabbage plantation can greatly reduce the occurrence of diseases of infectious origin. The cultivation of Savoy cabbage should be established on sites free from dangerous soil-borne pathogens, such as the pathogen of clubroot, which affects other plants of the Brassica family (e.g. broccoli,

cauliflower, Brussels sprouts, white head cabbage, radish, arugula), often leading to significant losses in vegetable yield.

During the vegetation period, Savoy cabbage can be infected by fungal, fungus-like, bacterial, and slime mould pathogens. The most common diseases occurring on Savoy cabbage plantations are: seedling blight, clubroot, black spot (alternaria), grey mould, downy mildew, black rot of crucifers, and bacterial soft rot.

V.1. List of the most important diseases and their characteristics

In order to detect the first signs of disease early, regular plantation monitoring should be carried out during the period of potential threat for symptoms of the following diseases: seedling blight, clubroot, grey mould, black spot (alternariosis), black rot of crucifers, and wet rot of cabbage. The observations should be recorded in the integrated production notebook.

V.1.1. Diseases caused by slime moulds

Clubroot of cabbage —pathogen - *Plasmodiophora brassicae*

The pathogen of the disease infects more than 200 species of crops and weeds belonging to the Brassica family. The appearance of the organism on the plantation can lead to significant yield losses. What's more, spores of the pathogen can remain in the soil for up to 20 years without losing their ability to infect. Symptoms of the disease are initially pale yellow, and later brown bulges on the roots of infested plants. The growths then crack and rot. This is accompanied by an unpleasant smell. The cracking of the growths contributes to the spread of zoospores of the pathogen in the soil, which can infect subsequent plants. Inhabited by *P. brassicae*, the roots are hindered and over time completely prevented from transporting water and minerals, as a result of which the plant withers, turns yellow, and dies.

The development of the disease is facilitated by the location of cabbage plantations on wet and acidic soils and soil temperatures ranging from 20 to 25°C. Exacerbation of symptoms caused by *P. brassicae* on the roots of plants depends on the amount of pathogen in the soil.

<u>Prevention and control:</u>

- Use a minimum 4-year crop rotation.
- Sow seed material of at least standard category into a substrate free from pathogens. Locate Savoy cabbage plantations on permeable soils, with good structure, without a tendency to water stagnation.
- In the year preceding the cultivation of Savoy cabbage, it is mandatory to determine the soil reaction, confirmed by the results of an analysis, and conduct liming (limits the development of cabbage clubroot) if the soil analysis reveals such a need. Liming of acidic soils (at pH below 6.0) with fertilisers in the form of oxide or hydroxide is recommended.

- In the event of a threat from *P. brassicae*, it is necessary to conduct a soil analysis for the presence of the pathogen in a specialised laboratory. After finding the pathogen in the soil, do not grow plants of the Brassica family on a given field.
- In the cultivation of Savoy cabbage, take into account precursor crops that accelerate the disappearance of spores of *P. brassicae*, i.e. leek, tomato, oats, buckwheat.
- Thermally decontaminate seedling substrates (80-90°C for 30 minutes).
- Conduct monitoring of the plantation for the presence of clubroot at least once a week.
- Remove and destroy the infested roots as soon as possible after the onset of disease symptoms and before the observed growths begin to crack and rot.
- Introduce varieties resistant or tolerant to clubroot for cultivation.
- Disinfect tools and equipment intended for maintenance work.

V.1.2. Bacterial diseases

Wet rot of cabbage heads – pathogen – bacterium *Pectobacterium carotovorum* subsp. *carotovorum*, *Pseudomonas marginalis*

The disease is common in many species of vegetable plants. In the cultivation of Savoy cabbage, the pathogen is particularly dangerous at the stage of harvest maturity of the heads and during the storage period. The first symptoms are observed on the heads of cabbage in the form of small spots, appearing water-soaked. These changes are rapidly expanding and cover the entire heads of cabbage. Tissues affected within the spots are soft and disintegrate, and on their surface, there is a wet, mucous mass that can flow to the ground. Infected plants are most often colonised by saprophytic bacteria, accompanied by an unpleasant smell of rot. If the environmental conditions are favourable for the development of the pathogen, then not only the entire heads of cabbage, but also the entire lower parts of the stems undergo wet rot.

During the growing season, the growth of bacteria is facilitated by an air temperature of 15 to 30°C, frequent, long periods of rainfall, and irrigation of the plantations. However, during the period of long-term storage, the humidity of the air in the storage room exceeds 90 %.

Bacteria are more likely to occur at sites where soils are moist, cohesive, and impermeable, and where excessively high doses of nitrogen-containing mineral fertilisers have been applied. Infection occurs through minor damage resulting from the feeding of pests, ongoing care work or natural cracks, as well as a result of infection by other pathogens. Pests feeding also contribute to the spread of bacteria.

The pathogen survives in soil and on infested plant parts in storage and in the field. Water used for irrigation can also be a source of infection.

<u>Prevention and control:</u>

- Use a minimum 4-year crop rotation.
- Sow seed material of at least standard category into a substrate free from pathogens.

- Conduct monitoring of the plantation for the presence of wet rot in cabbage heads at least once a week.
- Perform care treatments during dry, sunny weather.
- Remove and destroy plants with disease symptoms.
- Limit excessive watering of plants during the growing season.
- Disinfect equipment for washing, packaging, pallets, boxes, and cold stores.
- Maintain optimal temperature in the storage room.
- Systematically review box pallets with stored cabbage and eliminate sources of disease.
- Thoroughly remove post-harvest residues after the end of the production cycle.

Black rot of crucifers —pathogen - bacterium *Xanthomonas campestris* pv. *campestris*

The pathogen of the disease is a dangerous pathogen found on all Brassica plants and often develops in storage, causing significant yield losses. During the vegetation period, disease symptoms occur mainly on aerial parts of plants. Most often, the first symptoms are visible in the second half of July during periods of high humidity and air temperature (25-30°C). On the fringes of the leaves, slightly yellowing, chlorotic spots resembling the letter 'V' are formed. The spots gradually enlarge, and chlorosis spreads to the main vein of the leaf and the lateral veins, around which the tissue undergoes chlorosis and then blackens. Symptoms then cover the entire surface of the leaves, which later blacken, dry up, and fall off. The infection of the conductive bundles reaches deep into the cabbage heads. Symptoms of head infection caused by *X. campestris* pv. *campestris* can be observed at the time of harvest. Then at their base, on the cross-section of the stump, a blackening ring of conductive bundles is visible. Such infected plants are not suitable for storage.

The source of infection is infested plant residues in the soil and seeds. The bacterium can also occur and survive the winter on some weeds, such as field cabbage and black mustard, and in the spring, under favourable conditions, infect crops.

The bacterium penetrates into the roots of the host plant through small wounds, and further into the conductive bundles through which it is transported throughout the plant. Infestation of the leaves occurs through stomata, hydathodes or natural wounds, from where the pathogen spreads throughout the plant.

Prevention and control:

- Use a minimum 4-year crop rotation.
- Sow seed material of at least standard category into a substrate free from pathogens.
- Conduct monitoring of the plantation for the presence of black rot of crucifers at least once a week.
- Perform care treatments and harvests during dry, sunny weather.
- Remove and destroy plants with disease symptoms.
- During the growing season, limit excessive sprinkling of plants.
- Disinfect equipment for washing, packaging, pallets, boxes, and cold stores.
- Maintain optimal temperature in the storage room.
- Systematically inspect box pallets with stored cabbage and eliminate sources of disease.

- Introduce varieties of cabbage resistant to *X. campestris* pv. *campestris*.
- Thoroughly remove post-harvest residues after the end of the production cycle.

V.1.3. Diseases caused by fungal and fungal-like organisms

Seedling blight — pathogens: *Pythium* spp. and fungi of the genus *Fusarium*, *Rhisoctonia*, *BoBotrytis*, *Alternaria* and *Sclerotinia*

Pathogens causing seedling blight can infest seeds or reside in the soil. There are two types of blight: pre-emergence and post-emergence. Pre-emergence blight occurs before the appearance of the aerial parts of the plant as sprout dieback. Post-emergence blight is observed after the appearance of seedlings, which individually or in patches grow less vigorously, turn yellow, and die. Infested plants show browning and narrowing of the root neck. The youngest infested roots turn brown and disintegrate with a gentle pull. Due to the fact that the disease is caused by a complex of pathogenic microorganisms, depending on the environmental conditions (temperature, humidity), the species variability of the pathogens can be observed. The problem of seedling blight often arises if the seeds are sown too deeply, into a moist or waterlogged, cold substrate. The risk of disease also increases when untreated seeds are sown and at high density.

Prevention and control:

- Sow seed material of at least standard category into a substrate free from pathogens. Conduct monitoring of the plantation for the presence of seedling blight at least twice a week.
- Remove and destroy plants with disease symptoms.
- Sow seeds in plant trays.
- Thoroughly remove post-harvest residues after the end of the production cycle.

Black spot (cabbage alternariosis) — pathogens: fungi *Alternaria brassicae*, *A. brassicicola*, *A. alternata*

The agents of the disease infect cabbage leaves. The first signs of disease in the form of concentric spots of different sizes occur on the oldest leaves of Savoy cabbage. The spots are dark-coloured, surrounded by a yellow border. On the surface of discolouration, a velvety, dark brown coating of conidia spores is visible. Pathogens can overwinter on the remains of post-harvest plants and weeds of the Brassica family. Fungi of the genus *Alternaria* are also transmitted by seeds, which are the primary source of infection. During the vegetation period, the conidial spores of the pathogen are transmitted by wind and water. Mass infection of plants occurs when the air temperature is 20-27°C and the air humidity is 95-100 %.

Prevention and control:

- Use a minimum 4-year crop rotation.
- Sow seed material of at least the standard category.
- On the Savoy cabbage plantation, carefully destroy plant residue and weeds from the

Brassica family.

- Conduct monitoring of the plantation for the presence of black spot at least once a week.
- At the time of threat, based on the analysis of weather conditions or the appearance of the first symptoms of disease, it is recommended to alternately spray the Savoy cabbage plants with fungicides with different mechanisms of action, recommended for use in IP.

Grey mould – pathogen: fungus *Botrytis cinerea*

The disease is common on crops belonging to many species. The first symptoms of grey mould on the leaves of Savoy cabbage are initially watery, different-sized spots that over time acquire a brown colour. Then the discolouration is covered with a plentiful coating of conidial spores of the fungus. The infection pathway for the pathogen consists of any mechanical damage to the plant tissues and damage caused by other pathogens or insects. Fungal spores are spread by wind and water. Optimal conditions for the development of *B. cinerea* are cool and humid weather. Grey mould may only become apparent during storage, leading to the rotting of Savoy cabbage heads.

Prevention and control:

- Adequate hygiene must be maintained in the field and in storage areas.
- Conduct monitoring of the plantation for grey mould at least once a week.
- At the time of threat, based on the analysis of weather conditions or the appearance of the first symptoms of disease, it is recommended to alternate spraying of Savoy cabbage plants with fungicides, with different mechanisms of action, recommended for use in IP.

V.1.4. Fungal-like diseases

Downy mildew - pathogen: *Hyaloperonospora parasitica*,

The pathogen of the disease has a wide range of hosts and, in addition to Savoy cabbage, it can also infect mustard, horseradish, radishes, field pennycress, and other Brassica vegetables (Chinese cabbage, broccoli, cauliflower, etc.).

The most dangerous of them is in areas of intensive cultivation of vegetables from the Brassica family. Infection can occur already in the seedling production phase. On the upper side of the cotyledons and leaves of the seedlings, initially yellow and later browning spots are visible, within which, under conditions of high air humidity, white or white-grey clusters of pathogen spores form on the lower side of the cotyledons and leaves. Infested seedlings are weakened, turn yellow and gradually die off.

During the vegetation period of Savoy cabbage, similar symptoms can be observed on plants infected by *H. parasitica*. On the upper side of the leaf blades, chlorotic spots appear, which are initially yellow and later become brown. The resulting changes may be limited by nerves. On the underside of the leaf blade within the spots, under conditions of high air humidity, a white or greyish-white, abundant coating of spore-forming mycelium forms. The pathogen develops in cool and humid weather when the air temperature is between 10-16°C at night and 23°C during the day. *H. parasitica* produces sporangial spores that cause secondary

infections. They spread easily during rainfall and watering, and higher air humidity promotes their germination and plant infection.

Prevention and control:

- Implement a minimum 4-year crop rotation.
- Sow seed material of at least standard category into a substrate free from pathogens.
- On the Savoy cabbage plantation, carefully destroy plant residue and weeds from the Brassica family, on which *H. parasitica* can overwinter.
- Irrigate the plants in the morning so that the surface of the leaves is moistened for as short a time as possible during the day.
- At the time of threat, based on the analysis of weather conditions or the appearance of the first symptoms of disease, it is recommended to alternate spraying of Savoy cabbage plants with fungicides, with different mechanisms of action, recommended for use in IP.

V.2. 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 the regular inspection of the occurrence of harmful organisms (pathogens, pests, or weeds) on plantations. This action requires the identification of the harmful organism to be observed, the choice of 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 Savoy cabbage. The prevention and control of pests in Savoy cabbage crops should be carried out on the basis of pathogen signalling and, for example, on the basis of the Vegetable Plant Protection Programme, developed annually by a team of employees of the Institute of Horticulture – National Research Institute. Communications on current pest risks also facilitate decision-making.

V.3. Types of disease prevention

Preventing the occurrence and spread of harmful organisms in the cultivation of Savoy cabbage involves the application of phytosanitary hygiene measures, which include the following elements of cultivation:

- 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. These residues are the site of wintering for certain pathogens (e.g. the agents of clubroot, black spot) and pests.
- Preventing weed seeds from entering Savoy cabbage plantations from neighbouring areas and preventing weeds from releasing seeds on the margins, slopes, or shoulders. This is particularly important for those species whose seeds can be easily carried by wind or animals. Blooming weeds can attract pests that infest Savoy cabbage, while weed seeds contribute to increased field infestation in subsequent years.
- Systematic observation of Savoy cabbage plantations and identification of harmful organisms, as well as determination of their severity and area of occurrence.

V.4. Non-chemical methods of controlling diseases of Savoy cabbage

V.4.1. The agricultural engineering method

Crop rotation. They are the basis for maintaining proper microbiological balance and soil health, as well as limiting the excessive multiplication of pathogens of soil origin, e.g. *P. brassicae*, *Alternaria* spp., *X. campestris* pv. *campestris*.

The cultivation of Savoy cabbage in monoculture promotes the spread of soil-borne pathogens. The correct crop rotation should take into account those arable plant species that are not hosts to the harmful organisms present at the site. Crop rotation involving the cultivation of Savoy cabbage should take into account at least a 4-year rotation of the plants. Savoy cabbage should not be grown in locations after perennial Fabaceae (alfalfa, clover), beetroot, spinach, and other brassicas (including rapeseed, mustard, swede). It is advisable to plant after annual Fabaceae, potatoes, tomatoes, cucumbers, onions, leeks, celery, and cereals. In the cultivation of Savoy cabbage, weeds should be thoroughly destroyed, and varieties resistant or tolerant to certain pathogens should be introduced.

Location of plantations. Choosing the right plantation location can limit the spread of the agents of diseases that pose a threat to the cultivation of Savoy cabbage (e.g. clubroot). The site for growing Savoy cabbage should be free from the pathogen causing clubroot. Avoid establishing plantations in the vicinity of, for example, clover, alfalfa, rapeseed, as well as near crops of winter and spring oilseed rape. Their proximity increases the likelihood of developing diseases (e.g. black spot).

Soil mechanical cultivation. Timely performance of mechanical tillage of soil, such as deep ploughing, cultivating, harrowing, or subsoiling, has a significant impact on the elimination of waterlogging in the field and the improvement of soil structure. It should also be noted that soil-borne pathogens, such as the pathogen of clubroot, can be transferred on the wheels of machinery and cultivation tools to adjacent fields.

Regulating the times of sowing and harvesting. Sowing and planting seedlings of Savoy cabbage at an earlier or delayed date has an impact on limiting the losses caused by disease agents. Early cultivation of Savoy cabbage, e.g. under cover, is not infected by the agents of black spot (alternariosis) and is not inhabited by certain pests, but these pests can appear on

late varieties and contribute to significant losses in the yield of heads. Planning too late for harvesting exposes plants to infection from *Alternaria* spp. or *B. cinerea*, and also reduces the storage value of cabbage heads.

Fertilisation. Proper mineral fertilisation of cabbage has a significant impact on its health. Organic fertilisation with manure and compost has a positive impact on the reduction of pathogens, as beneficial microorganisms introduced into the soil stabilize the microbiological balance. An important element of fertilisation is supplementing the deficiency of potassium, molybdenum, boron, and calcium. Their optimal content in the soil reduces the likelihood of physiological diseases and increases the defensive and regenerative capacities of plants.

Weed control. Allowing the development of weeds on the Savoy cabbage plantation may promote the spread of certain diseases, e.g. the pathogen of downy mildew in Brassica. In addition, many species of weeds belonging to the same family as cabbage are hosts for *P. brassicae*, the pathogen of clubroot, as well as pathogenic bacteria. Maintaining a weed-free head cabbage plantation is one of the basic principles of hygiene and phytosanitary treatments.

Phytosanitary hygiene measures. Accurate removal of crop residues and parts of infested plants is a measure to prevent or reduce the occurrence of many agents of diseases of fungal or bacterial origin, as they serve as their overwintering sites, e.g.: *H. parasitica*.

V.4.2. Cultivation method

Important criteria for the selection of varieties in integrated production are their resistance or tolerance to the most dangerous diseases (e.g. black rot of crucifers, clubroot of cabbage), low susceptibility to adverse climatic factors, the formation of a strong root system, the ability to make maximum use of nutrients, and tolerance to cold (high frost resistance). The use in cultivation of the beneficial characteristics of the available varieties of Savoy cabbage allows for obtaining a commercial yield at an appropriate level.

V.4.3. Biological method

The biological method is successfully used in many vegetable crops under cover, and less often in field crops. In the protection of Savoy cabbage, a product based on the antagonistic organism *Coniothyrium minitans* is approved for use, which should be applied to the soil. The availability of biological products should be verified against the current list of plant protection products for IP in vegetable crops.

V.5. Chemical measures to fight diseases

V.5.1. Preventive method

The preventive method involves the use of means in the form of seed treatment, watering seedlings, and the use of soil granules before the appearance of the agents of diseases in the field.

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

V.5.2. Intervention method

It involves the use of registered and approved fungicides for integrated production at the onset of the first symptoms of the disease on individual Savoy cabbage plants in a specific plantation and/or in the immediate vicinity, or as indicated by alerting devices. This applies mainly to downy mildew of Brassica, grey mould, and black spot (alternariosis).

V.5.3. Characteristics of the protective agents used in the cultivation of Savoy cabbage against diseases

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

VI. PESTS

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6.1. Description of harmful species, prevention and control

Below are described the most common pest species on Savoy cabbage and methods of their controlling. These include: cabbage fly, cabbage aphid, vegetable whitefly, tobacco thrips, various species of moths, as well as flea beetles, weevils, and soil pests (cutworms).

VI.1.1. Cabbage fly - *Delia radicum* L.
family: Anthomyiidae

It occurs annually and in all areas cultivating Brassica plants, contributing to significant damage.

Type of damage. The harmful stage is the larvae, which bore winding, shallow tunnels in the organs of plants. The greatest threat is posed by the larvae of the spring generation, which, after planting cabbage seedlings, feed in the main root and root neck of plants, causing plant death. Damaged plants grow poorly, wither, and are easy to pull out of the ground. The larvae of the summer generations, in addition to the roots, also feed in the thicker veins of the leaves, boring tunnels. Damaged cabbage heads are devoid of commercial value.

Pest description. Adult flies reach a length of approximately 6 mm. Their bodies are grey in colour, covered with grey bristles. The wings are colourless. The eggs are approximately 1.2 mm in length, oblong, whitish, with a reticular pattern on the surface. The larvae are 7 to 10 mm long, white or pale yellow, legless, with a wreath of appendages at the end of the body. The pupae (chrysalides) are 5 to 6.5 mm long, initially yellowish-brown, and over time they turn brown.

Biology outline. This fly develops 2-3 generations during the growing season. The pupae winter in the soil. The emergence of flies of the wintering generation occurs when the soil temperature reaches 10°C, which usually happens at the turn of April and May and lasts until June. After about a two-week period of supplementary feeding, females of this generation lay eggs on the ground near the root collar of plants or directly on the root collar. The larvae feed in May and June. Pupation occurs in the soil. The emergence of flies of the first summer generation occurs at the turn of June and July, while the second generation emerges at the beginning of September (the activity of the first and second generation insects may overlap in time).

Monitoring and threat thresholds. In order to determine the dates for the eradication of cabbage fly on the plantation, it is recommended to carry out monitoring, preferably using traps with a fragrance attractant that attracts fertilised females. These traps, in the number of 2 per plantation regardless of its area, are set from the first decade of April to mid May and monitored every 2-3 days for 4-5 weeks. To observe the flight of summer generations of the cabbage root fly, traps should be set from mid July to the middle of the first decade of September and checked every 2-3 days for 7-8 weeks. The threat threshold is the capture of two females per day (average of 2 traps) for two consecutive days. **Plantations should also be monitored (at least once a week) during the period from May to June for the presence of damaged or destroyed Savoy cabbage plants by cabbage root fly, and the results of the observations recorded in the integrated production notebook**.

Prevention and control. Soil cultivation plays an important role in reducing cabbage fly. Deep pre-winter ploughing, as well as other tillage operations (harrowing, cultivating), serve to bring pest larvae or pupae to the surface, where they fall prey to birds or predatory insects, are dried by the sun, or exposed to low temperatures. It is also important to adhere to the correct crop rotation — it is necessary to avoid cultivating plants of the Brassica family more frequently than once every four years on the same site. Due to the fact that after planting cabbage seedlings, the source of food for adult cabbage fly insects is the nectar of flowering plants, weeds should be controlled on the plantation and in its immediate surroundings before they bloom. It is also recommended to establish cabbage crops away from long- and abundantly flowering crops (e.g. clover, alfalfa). An inadvisable neighbourhood for cabbage plantations is rapeseed crops, which are also a host plant for the cabbage fly and can be a reservoir of the pest. In addition, manure should be carefully incorporated, and spring application of this fertiliser avoided, as it can attract pests. In small-scale cultivation, it is possible to cover cabbage with non-woven fabric or mesh (1×1.5 mm mesh) to make it difficult for pests to access plants and lay eggs. There have been reports

indicating the reduction of losses caused by the cabbage root fly through the use of beneficial organisms. The biological method of pest control involves, among other things, the use of entomopathogenic nematodes. The cabbage root fly population may also be limited by its natural enemies, in particular beetles from the Carabidae and Staphylinidae families and parasitic Hymenoptera.

VI.1.2. Flea beetles (*Phyllotreta* spp.)
family: Chrysomelidae

Among the flea species inhabiting Savoy cabbage plantations, the most important are: the black flea (*P. atra* Fabricius), the striped flea (*P. nemorum* L.), and the wavy flea (*P. undulata* Kutschera).

Type of damage. The major threat comes from beetles, as they feed on cotyledons and leaves of cabbage, creating holes or cavities in them. Damaged plants have a smaller assimilation area and are at greater risk of water loss than healthy ones, which is especially dangerous for young plants. The development of fleas and the severity of the losses caused by them are facilitated by hot and rainless weather. The larvae of the striped flea beetle mine the leaves, while the larvae of other species feed on the roots, usually without causing any serious damage.

Pest description. Wavy-striped flea beetles are 1.8-2 mm long, black flea beetles are 1.7 to 2.5 mm long, and striped flea beetles are 2.5 to 3.5 mm long. They differ in the pattern on their elytra. The beetles of the striped flea beetle are black, metallic-glossy, with two yellow stripes of the same width on the wing covers. In the wavy-striped flea, the yellow stripes in the middle are narrowed and at the end widened. The black flea beetles are black with a green, metallic lustre. They move by jumping. The larvae of these flea species are similar to each other. They are light yellow, with darker spots on the upper side of the body, and have three pairs of legs.

Biology outline. Beetles overwinter under plant residue, in the top layer of soil near foraging sites, often also in strips of wild vegetation on the outskirts of the plantation. In the spring, usually at the turn of April and May, when the air temperature reaches 14-16°C, the beetles leave the wintering sites, feed on weeds of the Brassica family, and then inhabit planted seedlings or emerging plants of Brassica vegetables. The laying of eggs by fertilised females takes place in the period from late May to mid July. In July, fleas of a new generation appear, which after a period of feeding move to wintering places.

Monitoring and threat thresholds. Plantation monitoring should be carried out at least once a week from the moment the seedlings are planted in the field. During the monitoring, it is necessary to pay attention to both the presence of beetles and the damage caused by them to the leaves. The threat threshold is 2-4 beetles per 1 m^2 of crops.

Prevention and control. The presence of flea beetles is limited by proper soil cultivation, in particular ploughing, preferably deep, as well as other tillage operations (harrowing, cultivating). Cabbage plantations should not be located in the vicinity of other crops of the

Brassica family that can be inhabited by flea beetles (e.g. cauliflower), as well as in the immediate vicinity of rapeseed, which is a reservoir of the pest. It is appropriate to control weeds of the Brassica family on and near the plantation. Proper crop rotation should be observed – it is not recommended to grow Brassica plants more than once every four years on the same site. In addition, covering plants with non-woven fabric may reduce the losses caused by flea beetles, which limits the access of pests to them. Flea control should be carried out on the basis of monitoring using registered plant protection products. Control treatments should be carried out with particular care in the outer areas of the plantation, where flea pressure is usually the highest.

VI.1.3. Weevils (*Ceutorhynchus* spp.)
family: Curculionidae

In the cultivation of Savoy cabbage, the greatest threat is the cabbage stem flea beetle (*C. pallidactylus* Marshall); the cabbage stem weevil (*C. napi* Gyll.) and the gall-making weevil (*C. pleurostigma* Marshall) may also occur, as well as other species of local importance.
Type of damage. The harmful stage is the larvae, causing various damage depending on the species. The larvae of the weevil feed in petioles, stems, and less often in the roots. They also bite irregular holes in the leaf blade. The cabbage stem weevil larvae feed in the growth cone of young plants, as a result of which the cabbage head does not develop. At the site of damage, instead of the head, a rosette of distorted leaves grows. In turn, as a result of the feeding of the larvae of the gall-making weevil, growths develop on the main root. The transport of water and assimilates in the plant is disturbed, growth is limited, and it is possible for plants to die. Losses associated with the feeding of beetles have no economic significance.
Pest description. Beetles are 2 to 4 mm long, depending on the species. The cabbage stem weevil is black with a greyish-green tint, the rape stem weevil has an ashy body without spots, while the gall-making weevil is dark brown or dark grey. The larvae of the weevils are legless, 3 to 8 mm long, white to cream in colour, with a distinct brown-coloured head capsule.
Biology outline. There is one generation per year. Beetles overwinter in the soil, litter, under plant residue, often in strips of wild-growing plants surrounding the plantation (in the case of the gall-making weevil, larvae can also overwinter in the galls). After wintering and supplementary feeding, the females lay eggs (on leaves or cotyledons, root neck, soil, depending on the species), from which the larvae begin to forage on the plants.
Monitoring and threat thresholds. Plantation monitoring for the presence of beetles should be carried out from the planting of seedlings to the beginning of head formation, i.e. from April to July, with a frequency of at least once a week. 2-4 beetles on 25 consecutively examined plants are assumed to be the threat threshold.
Prevention and control. The population of the pests on the plantation is limited by mechanical soil cultivation. During planting of seedlings, plants with symptoms of foraging by

the gall-making weevil should be removed. It is also recommended to cover the plantation with non-woven fabric or nets.
Control of weevils should be carried out on the basis of monitoring with registered plant protection products. Combat treatments are recommended to be carried out with particular care in the marginal parts of the plantation, where these pests occur with the greatest intensity.

VI.1.4. Aphids
family: Aphididae

The biggest threat to Savoy cabbage is: cabbage aphid - *Brevicoryne brassicae* L.) and peach aphid — *Myzus* (*Nectarosiphon*) *persicae* (Sulzer). The peach aphid, although it occurs with much less intensity, should also be controlled, as it is a vector of dangerous viruses affecting plants of the Brassica family.
Type of damage. Aphids feed on the leaves, causing them to turn pink-violet, distort, and curl. Plants infested by aphids are weakened, and their growth is limited. In the case of a strong infestation of the middle leaves, cabbage may not form a head. In addition, the leaves of plants heavily infested by aphids are contaminated with honeydew secreted by them, and sooty mould fungi growing on it cover the leaves with a black coating. The indirect harmfulness of aphids, consisting in the transmission of plant viruses by them, which may cause significant losses even with a relatively small population of these insects, is also significant.
Pest description. Wingless **cabbage aphids** reach up to 2 mm in length, are grey-green, and are covered with a grey wax coating. On the dorsal side, two rows of dark spots are visible. In winged individuals, the head and trunk are black, and the abdomen is green. Wingless individuals of the peach aphid are usually slightly larger, reaching up to 3 mm in length, and are green, yellowish-green, or pink. In winged individuals, the head and trunk are dark, and the abdomen is olive green. On the head, antennae are visible, and in the final part of the abdomen, two slightly bloated siphons.
Biology outline. Cabbage aphid develops 6 to 8 generations per year. It overwinters in the egg stage on the remnants of vegetables left after harvesting, on the transplants in storage, or on wild plants of the Brassica family. Initially, the population develops on weeds or seed plantations, from where winged individuals fly in June to Savoy cabbage plantations, where they form colonies.
Peach aphid can develop from a few to several generations in a year. It winters in the form of eggs on trees of the genus *Prunus*, primarily on peach trees and other plants, such as common wolfberry. The peach aphid can also overwinter in greenhouses on the plants grown there, developing continuously. The first generations of the peach aphid (usually three) develop on the winter host, then the winged individuals fly in May to herbaceous plants, including Savoy cabbage. It is also possible for aphids to develop in a greenhouse on seedlings, which are then transferred to the field. Aphids of both species are characterized

by high fertility and, under favourable conditions, very rapid development, which results in large colonies on plants.

Monitoring and threat thresholds. From the beginning of the period of formation of the first colonies by winged aphids, the plants should be inspected at least once a week, with particular attention paid to the underside of the leaves. An average of 60 aphids on 10 consecutive plants is assumed to be the threat threshold.

Prevention and control. It is necessary to deeply incorporate the remains of plants after harvest, on which the cabbage aphid can overwinter. In addition, maintain spatial isolation from crops that can act as a pest reservoir (e.g. peach orchards in the case of the peach aphid). Carry out proper protection of plants already at the stage of seedling production, and establish the plantation only with seedlings free of aphids. Weed control in the plantation environment limits the availability of host plants for pests. Balanced nitrogen fertilisation prevents excessive growth of plants with poorly developed mechanical tissues, which promotes the development of aphids. The population of aphids can be effectively limited by its numerous natural enemies, including: larvae and adult ladybirds and soldier beetles, predatory bugs of the families Miridae and Anthocoridae, larvae of Chrysopidae, Cecidomyiidae and Syrphidae, as well as parasitic wasps, e.g. aphidiine Hymenoptera of the family Braconidae. The presence of natural enemies in the area of vegetable crops, including Savoy cabbage, can be supported by leaving field scrub or creating places for them that abound in food, e.g.flower strips.

The basis for the protection of populations of natural enemies of pests in crops is to perform, as far as possible, treatments with insecticides selective for beneficial entomofauna.

Control of aphids should be carried out with registered plant protection products on the basis of regular inspections, as early as possible after the threat threshold has been exceeded, in order to avoid the spread of pests on the plantation. Biological or biotechnical preparations should take precedence over conventional plant protection products.

VI.1.5. Vegetable whitefly (*Aleyrodes proletella* (L.))
family: Aleyrodidae

Type of damage. It occurs annually on Brassica plants, including Savoy cabbage, where it poses a significant problem in cultivation. Not all its varieties are inhabited equally by this pest. Adults and larvae feed on the underside of the leaves. They suck plant juices, smooth the plants, weaken their growth, and cause the leaves to turn yellow. Insects secrete abundant honeydew, on which sooty mould fungi develop, covering the leaves with a black coating, thereby limiting gas exchange and the assimilation surface of plants.

Pest description. The adult insect is 1.5 to 2 mm long. The head and thorax are dark, and the abdomen is yellow, covered with a waxy powder. Dark spots are visible in the central part of both wings (this is a feature that allows distinguishing the vegetable whitefly from the similar-looking greenhouse whitefly). Eggs are longitudinally oval, initially bright and transparent, and darken over time. The larvae are oval, flattened, yellowish-white, covered

with a layer of wax; young ones are mobile, while older ones are fixed to the substrate. The fourth stage larva (puparium) has characteristic red eyes.

Biology outline. In the climatic conditions of Poland, vegetable whitefly develops from 4 to 5 generations. It overwinters as adult (female) on host plants, including crops of the Brassica family (e.g. winter oilseed rape, kale) or many species of wild plants from different botanical families (particularly greater celandine). The first generation develops on the plant on which the pest has wintered. In the spring (around mid-May), females fly to B vegetables, where they lay eggs. The rapid and abundant development of whitefly is favoured by high temperatures.

Monitoring and threat thresholds. Monitoring of the presence of vegetable whitefly on the plantation should be carried out from the beginning of May until the end of the growing season. Yellow sticky boards, placed vertically up to 0.5 m above the plants, are used to capture the pest and should be inspected at least once a week. This method must be supplemented by regular, at least weekly, plantation monitoring, during which the underside of the leaves, where adults are present and eggs are laid, is examined. This is required as soon as individual specimens are observed.

VI.1.6. Tobacco thrips (*Thrips tabaci* Lind.)
family: Thripidae

Type of damage. Tobacco thrips, as a rule, do not cause serious economic losses on Savoy cabbage, but their occurrence in greater intensity is possible, especially when the plantation is located near the cultivation of onions. Larvae and adults suck cellular sap, initially from the outer leaves, and over time also inhabit the inner leaves. As a result of thrips feeding, small discolourations of various sizes and shapes appear on the leaves.

Pest description. It is a small insect, difficult to see with the naked eye. Adults have an elongated body measuring 0.8-1.2 mm in length, and are light yellow, grey-brown, or almost black. Narrow wings are arranged along the body. On the head, there are 7-segmented antennae. Unlike adults, larvae are wingless and yellow in colour.

Biology outline. During the year, 4 to 6 generations of the pest develop. Adult insects overwinter in the top layer of the soil, on bulb vegetables left in the field, in plant residues, on perennial plantations, in greenhouses and storage rooms. In early spring, they leave their winter hideouts and move to both cultivated and wild plants, on which they feed and reproduce. The larvae, after feeding, descend to the soil, where pupation occurs. The development of one generation lasts from 18 to 30 days and is accelerated by warm and dry weather.

Monitoring and threat thresholds. From the stage of 5 leaves to the stage when the heads reach their typical size, 50 plants should be inspected once a week (10 consecutive plants in a row in 5 randomly selected locations). The decision to eradicate is based on the finding of individual larvae or females on 10 plants sequentially surveyed before the heads of Savoy cabbage are formed. For monitoring, one can also use yellow or blue sticky boards, which should be hung at a height of about 30 cm above the plants.

Prevention and control. After establishing equipment, it is recommended to carry out careful cultivation of the site, including deep ploughing, in order to destroy plant residues. Weeds on the plantation and on its outskirts should be controlled, as many of them can be host plants for pests. Cabbage plantations should be established in spatial isolation from the cultivation of onions, leeks, greenhouses, and foil tunnels. It is necessary to control the development of thrips already on the seedlings stage and plant them in the field free from pests. The population size of thrips can be effectively reduced by their natural enemies, e.g. heteropteran bugs from the Anthocoridae family.
The control of thrips should be carried out on the basis of monitoring, using registered plant protection products, respecting the principle of priority of biological agents (containing entomopathogenic fungi) and biotechnical over chemical ones.

VI.1.7. Cabbage leaf sawfly (*Athalia rosae* (L.))
family: Tenthredinidae

Type of damage. Gluttonous larvae damage plants in seedbeds and in the field. They feed on plant tissue and, when present in high numbers, skeletonize leaves. In a short time, they can cause significant damage to plants. The greatest threat is posed by the first generation, occurring during the period of planting (or emergence) and growth of young plants.
Pest description. Adult insects are 6 to 8 mm long; males are smaller than females. The abdomen is orange, the head, the antennae, and partially the abdomen are black. The eggs are white, oval. Larvae resemble moth caterpillars in appearance; they are wrinkled and covered with fine warts, and when the plant is moved, they fall easily. They have 11 pairs of legs and reach a length of 2 to 20 mm. Initially, they are grey, then greenish-grey, and over time they darken to black in the older stages of development. On the sides of the body of the larvae, a lighter stripe is visible.
Biology outline. There are 1 or 2 generations per year. Larvae overwinter in cocoons in the soil near foraging sites at a depth of about 7-15 cm. Pupation occurs in spring, and adult Hymenoptera appear at the turn of May and June. Females lay eggs on the leaves of Brassica plants, including Savoy cabbage. The hatched larvae begin feeding for about two weeks. Then some of them pupate in the summer of the same year, giving rise to the second generation, while the others do so only after wintering.
Monitoring and threat thresholds. Plantation monitoring for the presence of larvae on plants should be conducted once a week, starting from the beginning of the flight of adults in May and August. The threat threshold is defined as the detection of an average of 1 larva per plant in June, during the seedling growth period, after examining 10 plants in succession, and 4 larvae per plant during the plant growth period, in a sample of 50 plants selected at random in 5 locations in the field.
Prevention and control. It is recommended to maintain the spatial isolation of cabbage plantations from other crops of the Brassicaceae family, including rapeseed, and to destroy weeds of the Brassica family. It is important to observe the correct crop rotation (the recommended break in Brassica cultivation at the same site is 4 years). The number of

overwintering larvae in the soil can be reduced by careful mechanical cultivation and by accelerating the planting of seedlings, so that during the period of high sawfly emergence, the plants are already in more advanced growth stages, making them less susceptible to damage.
In the case of a high occurrence of the pest confirmed by monitoring, it should be controlled using registered plant protection products, giving priority to biological and biotechnical preparations over chemical ones.

VI.1.8. Diamondback moth (*Plutella xylostella* L.)
family: Plutellidae

Type of damage. The greatest threat is posed by the first generation of caterpillars, which feed on the heart leaves, also damaging the plant's growth cone, as a result of which the cabbage does not form a head. Young caterpillars mine the leaves, while older caterpillars create 'windows' in them, leaving the lower epidermis intact. With a large number of occurrences of the pest, defoliation is possible.
Pest description. Moths have a wingspan of 15 to 17 mm. The forewings are brown with a bright, wavy streak visible; rear wings are grey, finished with fringing. Eggs are yellow-green, oval, and small in size, ranging from 0.25 to 0.5 mm. The caterpillars are up to 12 mm long, sparsely hairy, most often light green, but can also be brownish-green or yellowish. Their body is clearly divided into segments, with the middle ones being distinctly wider. The pupae are up to 8 mm long, surrounded by an openwork cocoon, initially light green, and darken over time.
Biology outline. Depending on the weather conditions, the pest develops 2 to 4 generations per year. The wintering stage is a pupa, hidden in a mesh-shaped openwork cocoon in plant residue. Females lay eggs on the underside of the leaves, individually or in clusters of several, along the veins. The first and largest generation of caterpillars appears in June, the second in July and August, and the third in August and September. After a period of feeding lasting, depending on the weather, about 24 days, the caterpillars pupate in cocoons formed on the underside of the leaves.
Monitoring and threat thresholds. From June to October, during the hatching and feeding period of the caterpillars, with particular emphasis on the beginning phase of head formation, 10 consecutive plants in a row should be monitored once a week, in 5 randomly selected places in the field (50 plants in total in the sample). The threat threshold is the detection of individual females or larvae.
Prevention and control. The initial population of the diamondback moth in spring can be limited by careful post-harvest cultivation, during which plant residue is destroyed along with the overwintering pupae on them. The pest population can also be reduced by its natural enemies — the eggs of the diamondback moth are parasitized by Hymenoptera of the Trichogrammatidae family, while ichneumonids are parasitoids of its caterpillars. The control of the diamondback moth should be carried out on the basis of monitoring, using registered plant protection products, with priority being given to biological preparations.

VI.1.9. White butterflies (*Pieris* spp.)
family: Pieridae

As pests of Savoy cabbage, the cabbage white (*P. brassicae* (L.)) and the small white (*P. rapae* (L.)) are significant.

Type of damage. The harmful stage of both species of cabbage white butterflies are caterpillars. In the cabbage white butterfly, young caterpillars feed in clusters, scraping the leaf tissue, while older caterpillars spread out on plants and feed mostly individually, sometimes in small groups, biting holes in the leaf blades and, in extreme cases, skeletonising the leaves.

In the case of the small white, the caterpillars feed individually from hatching, initially scraping the mesophyll, later biting holes in the leaves. Older caterpillars of this species can also bore into the heads of cabbage. Both cabbage white and small white caterpillars contaminate cabbage heads with faeces, which disqualifies them as commercial material.

Pest description. Moths of both species are quite similar. **Cabbage white** has a wingspan of 5 to 6 cm, while the small white is smaller with a wingspan of 4 to 5 cm. In the cabbage white, the background of the wings is white. In the upper corner of the front wings, there is a black, arched spot, and in females, additionally, a pair of round, black spots on each of the front wings. In both sexes, in the upper part of the back wings, there is a pair of black spots. With **small white**, the wings are white with a black spot in the apical part. The male has one black spot on the upper side of the wing, while the female has two black spots. The underside of the back wing is yellow. Female cabbage white butterflies lay yellow, oval eggs about 1.5 mm long on leaves in clusters of up to several dozen, while female small white butterflies lay eggs one at a time, slightly embedding them in the leaf tissue, making them more difficult to observe. Chrysalis in both species is closed, green or green-grey, with an oblong thin strip on the dorsal side.

Biology outline. Both species develop mostly two, sometimes three generations per year. The wintering stage consists of pupae attached to plant residue, green plants, trees or shrubs, fences, walls of buildings, and similar places. Cabbage white butterflies appear in April, and their flight ends in May. The flight of the small white butterfly begins later, in May. Female moths of both species lay eggs mainly on weeds of the Brassica family, on which caterpillars also feed. The flight of butterflies of the summer generation of the cabbage white takes place from July to the end of August, while for the small white it starts a little earlier, at the turn of June and July. The caterpillars feed on brassica vegetables until September. Under favourable conditions, a second generation appears.

Prevention and control. Preventive measures include the control of weeds from the Brassica family on the plantation and in its surroundings, as hosts of the spring generation of cabbage butterflies, as well as weeds from other botanical families before their flowering, as they can serve as a source of nectar for the cabbage butterflies and attract them to the growing area. In addition, the recommendations regarding the spatial isolation of plantations from the

cultivation of other Brassica plants should be followed. Careful post-harvest cultivation of plantations to destroy plant residues on which pupae can overwinter may also be important. In limiting cabbage butterflies, an important role is played by a parasitic Hymenoptera from the family Braconidae, the Apanteles. The control of cabbage butterflies should be carried out on the basis of monitoring, using registered plant protection products, with priority given to biological preparations.

Monitoring and threat thresholds. Plantation monitoring should be carried out from July to September, at least once a week. It consists of examining 10 consecutive plants in a row, in three locations, at equal distances along the diagonal of the field. On average, 3-4 egg deposits or 10 caterpillars on the 10 consecutive plants are assume as the threat threshold for the cabbage white butterfly, and for the small white butterfly, 1-3 caterpillars on the 10 consecutive plants.

VI.1.10. Cabbage moth (*Mamestra brassicae* (L.))
family: Noctuidae

Type of damage. Young caterpillars chew holes in the leaf blades, leaving the edges and veins of the leaves intact. Older caterpillars bore into the heads of cabbage, creating holes that become contaminated with faeces.

Pest description. Moths are quite large, with a wingspan of up to 4.5 cm. The wings of the first pair are olive-grey with distinct streaks and two spots on each wing. Eggs are greyish-violet or beige-grey, hemispherical, laid in clusters of several dozen pieces. The caterpillars are 4-5 cm long, initially light yellow after hatching, and over time they darken, taking on a colour ranging from green to brown to black.

Biology outline. There are two generations of the pest in a year. The chrysalises winter in the soil. The flight of the moths of the wintering generation begins at the turn of May and June. Moths are active at night. From eggs laid by females, caterpillars hatch after about 5-15 days and feed until mid July. After a period of foraging, the caterpillars descend to the soil, where pupation occurs. The flight of summer generation moths lasts from the end of July to September, and the caterpillars feed on brassica vegetables until October, after which they pupate.

Monitoring and threat thresholds. For monitoring, pheromone traps are used, at a rate of 2 per hectare, which should be placed at a height of approximately 30 cm above the plants before the start of the moth flight. The need to perform the procedure is already evidenced by the catching of the first males. In addition, in June and from August to September, at a frequency of once a week, 10 consecutive plants in a row (50 in total in the sample) should be inspected at 5 randomly selected locations for the presence of caterpillars. The threat threshold is the detection of 4 caterpillars in the sample.

Prevention and control. Soil cultivation treatments (in particular careful pre-winter ploughing) destroy the wintering pupae of the pest. It is recommended to control weeds on and around the plantation before they bloom, as nectar is food for cabbage moths.

Once the threat threshold is exceeded, a decision should be taken to control the pest, respecting the primacy of biotechnical and biological preparations over chemical ones. The correct timing of treatments, which should occur during the hatching and feeding period of young larvae, plays an important role in the effective control of cabbage moth caterpillars, as older larvae burrow into the heads and are difficult to access with insecticides.

VI.1.11. Silver Y (*Autographa gamma* (L.))
family: Noctuidae

Type of damage. This species is particularly dangerous during periods of mass outbreaks, observed once every dozen or so years. Caterpillars feeding individually create holes, skeletonize leaves, and contaminate plants with excrement.
Pest description. Moths have a wingspan of up to 4.5 cm. The wings of the first pair are dark brown with a silvery gamma-shaped (γ) spot. Eggs are spherical, white, laid in clusters. Caterpillars are green or green-yellow, approximately 4 cm in length, tapering towards the head. They move in a characteristic way, curling the middle part of the body upwards in the shape of a semicircle.
Biology outline. It is a migratory moth. The first generation arrives from Southern Europe, most often at the turn of May and June. Butterflies are active both during the day and at night. From the eggs laid on the underside of the leaves, caterpillars hatch after about two weeks and begin to feed. The pupation takes place on the underside of the leaves. Moths of the summer generation appear in July and August. In particularly favourable conditions, the development of the third generation is possible. In autumn, after the first cooling, some moths migrate south, where the pest winters. In mild winters, silver Y caterpillars can overwinter in Poland.
Monitoring and threat thresholds. From June to September, 10 consecutive plants in a row should be inspected once a week in 5 randomly selected locations in the field. The threat threshold is the detection of 4 caterpillars in the sample. Pheromone traps can also be used for monitoring the flight of silver Y.
Prevention and control. Weeds should be controlled on and around the plantation before they bloom, as adult silver Y moths feed on nectar.
When the threat threshold is exceeded, pest control should be undertaken, respecting the priority of biotechnical and biological preparations over chemical ones.

VI.1.12. Agrotinae (*Agrotinae*)
family: Noctuidae

The most common species include: turnip mot (*Agrotis segetum)*, dark sword-grass (*Agrotis ypsilon*), heart-and-dart (*Agrotis exclamationis*) and setaceous Hebrew character (*Xestia c-nigrum*).
The characteristic feature of all cutworms is that their caterpillars curl up into a ‘ball’ when resting or when disturbed. The caterpillars begin to feed in early spring, when the soil temperature exceeds 10°C. They damage the underground and aboveground parts of plants.

They cut the young plants at the base, pull them into their underground hiding places and eat them there. One caterpillar can destroy several plants, which, if they occur in large numbers on the plantation, causes thinning of the plants and the formation of so-called bald spots. Older caterpillars hide in the soil during the day and feed there, damaging the underground parts of the crops. At night, they come out onto the surface and bite into plants, which fall over; The caterpillars overwinter beneath the surface of the ground at the feeding site. Cutworms generally have a one-year development cycle. The threat threshold is 6 larvae per 1 m^2.

Prevention and control. The procedure for limiting the number of cutworms is ploughing directly after harvesting the crops and deep autumn ploughing. During these operations, many caterpillars die mechanically or are eaten by birds, Carabidae beetles, etc. In areas where cutworms have been found, fallow land where they find good conditions for their development should be ploughed. During the growing season, weeds that the females like to lay eggs on should be destroyed on and near the plantations. Compost soil intended for greenhouse cultivation must be sifted or chemically disinfected before use. In the event of damage to crops caused by weevils, intervention spraying should be used. On smaller areas and in crops under cover, lures can be used.

VI.1.13. Birds

Young plants, after being planted in the field, are very eagerly eaten by pigeons, rooks, and jackdaws. In order to protect seedlings from birds, it is recommended to use protective nets. After planting the seedlings in the field, various deterrents can be used, such as small windmills, shiny objects (foil, glass, sheet metal) and strings or threads suspended above the surface of the field (white and bright coloured cotton threads are easy to see against the background of the earth and birds avoid them).

VI.1.14. Lagomorphs

European hare *Lepus europaeus* (Pallas) and **wild rabbit** *Oryctolagus cuniculus* (L.) can cause significant damage to the Savoy cabbage plantation cultivated in the spring cycle. The damage caused by rabbits/hares can be expected when the plantation is located near young pine trees, hills and railway embankments, where the rabbit prefers to establish its colonies. In threat areas, the most effective method is to surround the plantation with wire or plastic nets. The fence should be about 1 m high.

In addition, on the edges of the plantation, it is necessary to set resting poles every 1/5 ha for birds of prey with a height of 2–4 m with a bar up, and in the case of larger plantations — several poles. Birds sit on the bar and look for their victims, not only herbivorous birds, but also hares and wild rabbits.

VI.2. Indirect methods of pest control in integrated protection of Savoy cabbage

VI.2.1. Agrotechnical method

Location of plantations. Cabbage plantations should be located with spatial isolation from winter and spring oilseed rape and other nectar-bearing crops, as well as annual flowering plants. Their proximity increases the likelihood of pests (cabbage fly, vegetable whitefly, cabbage moth). Poor location can lead to increased workload and expenditure.

The immediate vicinity of fields where brassica vegetables were grown last year should be avoided. This will minimise the threat from cabbage fly, tobacco thrips, and other pests, which in the spring, after leaving their winter hiding places, will pose a threat to Savoy cabbage. Maintaining phytosanitary hygiene helps to reduce the number of pests overwintering in the field and their transfer from one area to another. It mainly consists in thorough harvesting of the precursor plant and cleaning the working machinery of plant residues and soil lumps.

Crop rotation. In integrated pest management, crop rotation is a fundamental element in reducing the number of soil pests (cutworms and grubs). When planning crop rotation, it is necessary to maintain a minimum 4-year break in the cultivation of brassica vegetables (including cauliflower, head cabbages, Brussels sprouts, kale). If a large number of soil pests is found, crop rotation should take into account plant species that are not attractive from a nutritional point of view, such as mustard, buckwheat, rapeseed, and flax.

Soil mechanical cultivation. Correct mechanical cultivation of soil enables reduction of overwintering pest stages. It is important to use stubble cultivation immediately after harvesting the plants, which allows the pests wintering in the soil to be brought to the surface. Many of them may then be eaten by birds or, in dry weather, the soil will dry out, which will significantly affect their mortality. Deep ploughing in spring is especially recommended as a method of reducing the pupae of cabbage fly present in the soil.

Fertilisation. It should be estimated on the basis of soil analysis for nutrient content so that the plants have optimal nutrient conditions. However, nitrogen over-fertilisation should be especially avoided, as it increases the attractiveness of plants to pests, which are therefore more likely to colonise them. Phosphorus and potassium fertilisation encourages strong development of mechanical tissue and hinders pest feeding (e.g. thrips).

Fighting weeds. The presence of weeds in the fields promotes more intensive infestation of Savoy cabbage crops by pests. Some species of weeds may offer a substitute source of food for pests or a place of shelter and wintering. Moreover, flowering weeds are a source of food for adult flies and moths.

VI.3. Direct methods of pest control in the cultivation of Savoy cabbage

VI.3.1. Mechanical method

In the case of pests that are easy to find and occur in low numbers (e.g. caterpillars of silver Y, small white), a method of manual collection may be considered. The use of all kinds of barriers, such as nets around the field, reduces damage to plants by birds and hares.

VI.3.2. Chemical method

The decision to use zoocides should be made based on threat thresholds determined through visual inspection of plants or the capture of harmful species using tools designed to signal their presence. When engaging in integrated pest management, products with as short a grace period as possible should be used, especially in the case of interventions carried out when vegetables achieve consumption maturity. Among the zoocides used for pest control, the preferred ones include biological and selective measures, i.e. those which impact specific groups of organisms. Biological plant protection products must be used at least once per season (primarily before harvest), which should be confirmed by the purchase invoice of the product.

Plant protection products are to be applied according to the recommendations given on the label and in a manner that does not create a threat to human or animal health or to the environment.

VI.4. Principles of zoocide use

All plant protection procedures must be performed in optimal conditions for their effectiveness and in a way that maximises their biological activity, while minimising the doses. Due to the protection of the environment and the need to preserve biodiversity, repeated use of the same active substances against the same harmful organism should be avoided so that there is no 'compensation phenomenon' or immunisation. Another method for limiting the amount of the plant protection product being used is precise, spot application, i.e. only at the locations where pests exist.

When using plant protection products in the form of spraying, the air temperature, for most products, should be above 18°C and not exceed 24°C.
On high temperature days, the procedure must be conducted early in the morning, when the plants display full turgor, or later in the afternoon, not only due to performance but also phytotoxicity.

VI.5. Actions aimed at the protection of beneficial organisms

- use of plant protection products based on the actual threat to crops from pests, assessed on the basis of monitoring their occurrence and threat thresholds (if they are developed for a given pest);
- Avoidance of insecticides with a wide spectrum of activity and their replacement with selective products;
- resigning from protection in the case of low pest abundance, when it does not threaten to reduce yield, especially when there are numerous beneficial organisms in the crop;
- application of treatments on the edges of the field or only at specific points, if the pest is not present
  over the entire area under cultivation;

- supporting the presence of natural enemies in the area of vegetable crops, including Savoy cabbage, by leaving field margins, field shelters, and other ecological areas in the agricultural landscape or creating food-rich areas for them, e.g. flower strips, as they are the habitat of many species of beneficial insects;

- supporting the presence of pollinators in the vicinity of vegetable crops by leaving or creating food-rich areas for them, such as flower strips, as well as places of refuge and nesting, such as mason bee houses and bumblebee huts or mounds, with at least 1 per 5 hectares, and in the case of larger plantations – several;

- carrying out plant protection treatments during hours when bees are not active due to the time of day or weather conditions;

- providing appropriate protection to hives in a situation where the spray liquid can penetrate inside. Bees are protected by law, and therefore producers causing the death of bees in an unintentional or purposeful manner are subject to financial punishment. The correct use of plant protection products is supervised by the Provincial Plant Health Inspectorates, which accept reports of bee poisoning and carry out proceedings as a result of which the producer becomes obliged to cover the losses. Poisoning of mothers of wild bees (bumblebees) and female solitary bees (e.g. mason bees) in spring, when they are nesting and breeding, is particularly dangerous;

- creating appropriate conditions for the presence of birds of prey by placing resting poles for birds of prey with a height of 2-4 m on the outskirts of plantations, with a bar on top, at a density of 1/5 ha, and in the case of larger plantations, several poles.

VII. HARVESTING AND STORAGE OF SAVOY CABBAGE

Dr Maria Grzegorzewska

VII.1. Harvesting and preparation for storage

When cultivating Savoy cabbage for storage, late varieties, tolerant to low temperatures, are selected. Savoy cabbage is usually harvested only after white cabbage is harvested, i.e. from the beginning of November to mid December. Heads of late varieties, ready for harvest, can withstand frosts up to -9°C, and some varieties, so-called winter, even up to -15°C. Light freezing does not impair the quality and storage capacity of this vegetable. Winter varieties, in areas with mild winters, are left by producers in the field even until mid February.

Savoy cabbage forms heads that are less compact than those of white head cabbage due to the characteristic texture of the leaves, which are wrinkled and curly. During harvesting and storage, Savoy cabbage requires similar treatment as white head cabbage, but shows greater susceptibility to rotting, yellowing, and ageing.

Harvesting is carried out during dry weather when the crops are dry. Cabbage for storage is cut by hand with a sharp knife or cleaver. All activities during harvesting should be

carried out carefully and gently. Unnecessary touching of the cabbage heads should be avoided in order not to rub off the wax coating covering the leaves. The coating protects cabbage from the penetration of pathogens and slightly reduces transpiration. It is very harmful to knock the cabbage, as any mechanical damage (even invisible to the naked eye) causes an increase in respiration, transpiration, and accelerates rotting. Ideally, immediately after cutting the cabbage, clean it in the field of damaged outer leaves, leaving 2-4 protruding healthy leaves to protect the head from drying out and bruising. Then, lay the cabbage gently in pallet boxes and transport the boxes to the storage location. Using the above method, work on the harvest is improved, minimizing the number of necessary operations, which translates into a reduction in the workload, as well as limiting mechanical damage to the heads. When transporting cabbage from the field loose on trailers, it is necessary to ensure good cushioning to prevent damage to the goods during transport.

The maturity of the heads at the time of harvesting has a significant impact on the storage stability of the cabbage. Heads should be well-formed and properly compact, but not yet overripe. Therefore, sowing seeds for late harvest is done only in May. Continuously high chlorophyll content in the leaves of the head makes the cabbage more resistant to fungal diseases. Immature heads, i.e. insufficiently developed and still quite soft, tend to lose turgor during storage. If they are overripe, they are more susceptible to disease and decay. If the cabbage harvest takes place during relatively warm weather, it is very important to cool the heads to 0°C as soon as possible and keep the temperature and humidity at an optimal level.

VII.2. Storage conditions

The recommended temperature for storing Savoy cabbage is 0°C and the relative air humidity is 90-95 %. Increased temperature causes more rot and faster ageing. A slight frost is not harmful to Savoy cabbage, because due to the vesicular structure of the leaves and the looser structure of the head, access to oxygenated air to the inside of the head is not as difficult as in the case of white cabbage. Therefore, it can be stored at a temperature of -0.5°C. It is unacceptable to store Savoy cabbage together with fruits and vegetables secreting ethylene. Even very small amounts of this gas in the air (1-10 ppm) negatively affect the quality of cabbage, causing an increase in the intensity of respiration and other processes that accelerate rotting and ageing. In addition, there is yellowing and falling of leaves from the stump.

VII.3. Forms of storage

VII.3.1. Wintering in the ground

In areas with winters where temperatures do not fall below -15°C, winter varieties with high frost resistance can be left in the field, as they grew, until mid February. The cabbage is harvested in winter, immediately before dispatch for trade, or is sent for further storage in warehouses or cold stores. Moderate snowfall does not damage Savoy cabbage and even maintains high humidity, which protects the heads from drying out.

VII.3.2. Storage in mounds

In practice, Savoy cabbage is unlikely to be stored in earthen mounds, although it is possible, but one should expect much worse results than in the case of head cabbage. It is very important to protect the heads from drying in the mound, and at the same time quickly cool them to 0°C. Light freezing does not lead to damage to the inner heads, which is why the covering of the mound can be thinner than for white cabbage.

VII.3.3. Storage in storage facilities

The buildings should be well insulated so that they can maintain temperature and humidity at an optimal and uniform level throughout the storage period. In storages with gravitational ventilation (without active ventilation), the heads should be laid directly on the floor in piles, placed in special pens, or laid on shelves. The heads can also be packed into crates or pallet boxes. When laying piles, it is recommended that they do not exceed 2 meters of width at the base; the height should be up to 1.2 m and the length up to 5 m. The heads are placed stumps up. In pens with a width of up to 2.5 m, the heads are laid up to a height of 1.2 m. Cabbage placed on the shelves is laid in 2–4 layers, with free spaces at the top of each shelf. Cabbage in boxes or pallet boxes can be stacked to a height of 3-4 m.

In modern storage facilities, the active ventilation system allows for maintaining a more appropriate and even temperature and proper humidity throughout the mass of the stored goods.

VII.3.4. Storage in cold stores

The best results are obtained by storing the Savoy cabbage in refrigerated chambers where optimal temperature and humidity conditions can be ensured throughout the storage period. Cabbage crates or pallet boxes shall be arranged in such a way as to maintain free spaces between the walls and the cabbage packs and between the different stacks of packs, in order to ensure good air circulation in the chamber. Cabbages should be placed in batches in the cold store because they need to be cooled down quickly. Loading of the chamber should take place over 5-7 days. In such conditions, late varieties can be stored until the end of March. According to seed companies, some varieties can be stored in refrigerated conditions even until May.

VII.3.5. Storage in a controlled atmosphere

More and more producers in Poland are starting to use a controlled atmosphere to store Savoy cabbage. The recommended gas composition of the atmosphere is the same as for white head cabbage, i.e. 5 % CO_2 and 2.5 to 3 % O_2. In a controlled atmosphere, Savoy cabbage retains its fresh appearance longer, is less affected by disease and the chlorophyll content of the leaves decreases at a slower rate.

VIII. HYGIENE AND HEALTH PRINCIPLES

The producer shall ensure compliance with the following hygiene and health rules during harvesting and preparation for sale of fruit produced under the system of Integrated Plant Production.

A. Employee personal hygiene

1. Persons working in the harvesting and preparation for sale of vegetables should:

a) not carry or suffer from food-borne diseases;

b) maintain personal cleanliness, observe hygiene rules and in particular wash hands frequently at work;

c) wear clean clothing and, where necessary, protective clothing;

d) injuries and abrasions should be treated with a waterproof dressing.

2. The vegetable producer shall make sure that the persons working on harvesting and preparing them for sale:

a) have unlimited access to washbasins and toilets, cleaning products, paper towels or hand dryers, etc.;

b) have been trained in hygiene.

B. Hygiene requirements for crops prepared for sale The plant producer shall take appropriate measures to ensure that:

a) clean or consumption-class water is used to wash the crops as necessary;

b) crops are protected during and after harvesting against physical, chemical and biological pollution.

C. Integrated plant production hygiene requirements for packaging, means of transport and places for the preparation of crops for sale Under integrated plant production, the producer takes the necessary actions to ensure that:

a) rooms (including equipment), means of transport and packaging are kept clean;

b) farm and domestic animals have no access to the rooms, vehicles and packaging;

c) 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;

d) hazardous waste and substances are not stored together with crops prepared for sale.

IX. RULES FOR DOCUMENTATION IN INTEGRATED PLANT PRODUCTION

Dr Grzegorz Gorzała

Inherent in the cultivation of plants in the integrated plant production system is the maintenance or possession of various 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 (consolidated text: Journal of Laws of 2023, item 2501).

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

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

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

The application form should be completed with information such as:

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

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

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

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

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

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

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

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

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

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

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

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

Seed material - complete the table by entering information about the purchased material – variety, category, degree of qualification, quantity, and proof of purchase (invoice/proof of purchase, official label, marketing label).

Sowing (...) – record the amount of seed used in each field in the table. 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 notebook 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 pests set out in the integrated plant production methodologies.

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

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

It is possible for an agricultural producer to obtain an IP certificate by applying to a certification body. Forms for the relevant applications are available from the certification bodies. Along with the completed application for a certificate certifying the use of integrated plant production, the plant producer shall provide the certifying operator with a statement that the crop was carried out in accordance with the requirements of integrated plant production and information on the species and varieties of plants grown using the requirements of integrated plant production, the area of their cultivation and the yield size.

X. GENERAL RULES GOVERNING THE ISSUE OF IP CERTIFICATES

The plant producer concerned shall annually notify the certification body of its intention to use integrated plant production **within the time limit laid down in Article 55(2) of the Plant Protection Products Act of 8 March 2013**. The integrated plant production system is open to all producers. Notification of the intention to participate in the system is possible in paper form by post, in electronic form, and directly.

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

The certification body controls producers of plants who use Integrated Plant Production. Supervisory actions cover in particular:

- confirmation of completion of IP training,
- 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 properly accredited in keeping with the provisions of the Act of 30 August 2002 on the conformity assessment system or the provisions of Regulation (EC) 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 application 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 Plant Protection Products Act,
- conducts production and protection of plants according to detailed methodologies approved by the Main Inspector and made available on the website of the Main Inspectorate of Plant Health and Seed Inspection;
- applies fertilisation on the basis of the actual nutrient requirements of plants, determined in particular on the basis of soil or plant analyses, comply with plant protection requirements against harmful organisms, in particular those set out in the methodologies, in the production of plants,
- documents the proper performance of activities related to integrated plant production;
- 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. LIST OF MANDATORY ACTIVITIES AND TREATMENTS IN THE INTEGRATED PRODUCTION SYSTEM OF SAVOY CABBAGE

Mandatory requirements (compatibility of 100%, i.e. 18 points)			
Item	**Checkpoints**	**YES/NO**	**Comment**
1.	Crop rotation – non-cultivation of Savoy cabbage after Brassica plants (horseradish, rape, turnip rape, mustard, oil radish, turnip) in the same field more often than every 4 years, as well as after: spinach, beetroot and rhubarb (see chapter II. 2.2; 2.3).	❑/❑	

2.	Performance of winter ploughing in autumn, confirmed by a record in the integrated production notebook (see chapter II. 2.4).	❑/❑	
3.	Determining the soil reaction in the year preceding the cultivation of Chinese cabbage and liming (limits the development of clubroot) if soil analysis demonstrates such need. The cultivation of Savoy cabbage is also permitted if the determination of the soil reaction is carried out in the year of the beginning of cultivation, provided that the soil pH is within the range optimal for Savoy cabbage (see chapter II. 2.10; rozdz.V.5.1.1).	❑/❑	
4.	Chemical analysis of soil before the start of cultivation, determination of fertilising needs (confirmed by the results of soil analysis) and application of optimal fertilisation (see chapter II. 2.11; 2.12; 2.13).	❑/❑	
5.	With threat from *Plasmodiophora brassicae* (the cause of cabbage clubroot), performing soil analysis in a specialised laboratory for the presence of this pathogen, confirmed by the results of tests. After confirming the presence of the pathogen in the soil, not growing plants of the Brassica family on a given field. (see chapter V. 5.1.1).	❑/❑	
6.	Production of seedlings from seed of at least the standard category (or sowing in the field of such material) – keeping labels and proofs of purchase of seed, and if the seedlings are purchased keep the supplier's documents (see chapter II 2.5; V. 5.1.1; 5.1.2; 5.1.3; 5.1.4).	❑/❑	
7.	Monitoring of Savoy cabbage at least once a week, during the production of seedlings, for the presence of seedling blight and, later in the growing season, monitoring of plantations (at least once a week) for the presence of the following diseases: clubroot, black rot of crucifers, wet rot of cabbage, alternaria black spot, grey mould (see chapter V. 5.1.1; 5.1.2; 5.1.3).	❑/❑	
8.	Preventive/intervention control of black spot, grey mould and downy mildew only after detection of risk of infection based on an analysis of weather conditions and/or after the onset of the first signs of disease (see chapter V. 5.1.4).	❑/❑	
9.	Alternate use of plant protection products with different mechanisms of action in accordance with the list of plant protection products recommended for IP, in order to prevent pest resistance to pesticides (if possible) (see	❑/❑	

	chapter V. 5.1.3; 5.1.4).		
10.	Removal and destruction of plants with symptoms of pathogen infestation and physiological disorders to an extent that prevents further growth of plants (deformations, symptoms of rotting, advanced leaf necrosis) (see chapter V. 5.1.1; 5.1.2; 5.1.3)	❑/❑	
11.	The use of scented traps (2 pcs/plantation regardless of its area), shortly after planting the Savoy cabbage, to monitor the timing of the appearance of cabbage fly and checking them at least once a week (see chapter VI. 6.1.1).	❑/❑	
12.	Monitoring of Savoy cabbage plantations for the presence of aphids and vegetable whitefly (once a week) (see chapter VI. 6.1.4, 6.1.5,).	❑/❑	
13.	Monitoring of Savoy cabbage plantations for the presence of moth caterpillars, diamondback moth, cabbage white, small white, and cabbage moth (once a week) (see chapter VI. 6.1.8, 6.1.9, 6.1.10.).	❑/❑	
14.	Incorporation of biological or biotechnical agents into the programme of protection against pests and pathogens of plants (at least one treatment should be carried out with such a preparation) (see chapter III).	❑/❑	
15.	Determination of weed species in the field intended for the cultivation of Savoy cabbage, in the year preceding its cultivation, and entering their names in the integrated production notebook (see chapter IV 4.1.).	❑/❑	
16.	Mowing of uncultivated areas belonging to the same farm around the plantation (e.g. boundary strips, ditches, roads), at least twice a year (end of May/beginning of June and end of July/beginning of August) in order to prevent the release of seeds by weeds (see chapter IV 4.2).	❑/❑	
17.	Placement of ‘houses’ for mason bee or mounds for bumblebees in the amount of at least 1 per 5 ha, and for larger plantations – several units (see chapter VI. 6.5).	❑/❑	
18.	Creating suitable living conditions for birds of prey, i.e. building at least one resting pole per 5 ha, and in the case of larger plantations – several pieces (see chapter VI 6.5.)	❑/❑	
Note: Traps, flypaper boards and yellow vessels helpful in monitoring pest infestation on plantations should be positioned from the side of the expected pest infestation (trees)			

NOTE! The fulfilment of all the requirements on the list of mandatory operations and treatments in the integrated production system shall be documented in the Notepad of Integrated Plant Production.

XII. CHECKLIST FOR FIELD VEGETABLE CROPS

Basic requirements (100 % compliance, i.e. 28 points)			
No.	**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 systematically conduct control observations of the crops and record them in the Notebook?	❑/❑	
7.	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?	❑/❑	
8.	Is chemical protection of crops replaced by alternative methods wherever justified?	❑/❑	
9.	Is chemical plant protection carried out based on threat thresholds and the signalling of harmful organisms (wherever possible)?	❑/❑	
10.	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?		
11.	Are the applied plant protection products authorised for IP and use in a given crop or plant?	❑/❑	
12.	Is each use of plant protection products recorded in the IP Notebook taking into account the reason, date and place of use, the area of the crops, the dosage and the amount of the spray liquid per unit of area?	❑/❑	
13.	Were the plant protection treatments carried out under appropriate conditions (optimal temperature, wind below 4 m/s)?	❑/❑	
14.	Is the rotation of the active substances of the crop protection products used for the treatments respected, if possible?	❑/❑	
15.	Does the producer limit the number of treatments and the amount of crop protection products used to a necessary minimum?	❑/❑	
16.	Does the producer have measuring devices to precisely determine the quantity of the measured plant protection agent?	❑/❑	
17.	Are the conditions for safe use of the agents respected, as set out on the labels?	❑/❑	
18.	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?	❑/❑	
19.	Are prevention and withdrawal periods observed?	❑/❑	
20.	Are the doses and maximum number of treatments during the growing season specified on the label of a plant protection product not exceeded?	❑/❑	
21.	Are the sprayers referred to in the IP notebook in good technical condition and are their technical inspection certificates up to date?	❑/❑	
22.	Does the producer carry out systematic calibration of the sprayer(s)?	❑/❑	

23.	Does the producer have a separate space for filling and cleaning the sprayers?	❑/❑	
24.	Does the handling of residues of the spray liquid comply with the indications on plant protection product labels?	❑/❑	
25.	Are crop protection products stored in a marked closed room in such a way as to prevent contamination of the environment?	❑/❑	
26.	Are all plant protection products stored only in their original packaging?	❑/❑	
27.	Does the IP producer observe hygienic and sanitary principles, especially those specified in the methodologies?	❑/❑	
28.	Are appropriate conditions for the development and protection of beneficial organisms ensured?	❑/❑	

* Documentation rules will change on 1 January 2026 as a result of the application of Implementing Regulation (EU) 2023/564.

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 field marked according to the entry in the IP notebook?	❑/❑	
3.	Does the producer use the correct crop rotation?	❑/❑	
4.	Did the producer perform all the necessary agrotechnical procedures in accordance with IP methodologies?	❑/❑	
5.	Does the sowing material used (seeds, seedlings) meet the production and quality requirements?	❑/❑	
6.	Is the recommended catch crop used in cultivation?	❑/❑	
7.	Are steps taken on the holding to reduce soil erosion?	❑/❑	
8.	Are expired plant protection products stored separately in the plant protection products warehouse?	❑/❑	
9.	Are sprayers specified in the IP notebook used for the	❑/❑	

	treatment?		
10.	Are protective clothing and health and safety rules observed during care work, especially during spraying?	❑/❑	
11.	Are fertiliser application machines maintained in good working order?	❑/❑	
12.	Do fertiliser application machines allow for accurate dose determination?	❑/❑	
13.	Is each fertiliser applied recorded with regard to its form, type, date of application, quantity, location and surface?	❑/❑	
14.	Are fertilisers stored in a separate and specially designated room in a manner that ensures protection of the environment against contamination?	❑/❑	
15.	Does the producer protect empty PPP packaging against unauthorised access?	❑/❑	
16.	Is 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 to collect organic residues and sorted vegetables?	❑/❑	
19.	Are there first-aid kits near the workplace?	❑/❑	
20.	Are hazardous areas on the farm, e.g. plant protection product storage rooms, clearly marked?	❑/❑	
21.	Does the producer use consultancy services?	❑/❑	
	Total points		

Recommendations (implementation min. 20 %, i.e. 3 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Are soil maps drawn up for the farm?	❑/❑	
2.	Are inorganic fertilisers stored in a clean and dry room?	❑/❑	
3.	Has a chemical analysis of organic fertilisers been carried out in terms of nutrient content?	❑/❑	
4.	Is there an irrigation system on the farm that ensures optimal water consumption?	❑/❑	

5.	Is the irrigation water tested in a laboratory for microbiological and chemical contamination?	❑/❑	
6.	Does the lighting in the room where the plant protection products are stored make it possible to read the information on the packaging of the plant protection products?	❑/❑	
7.	Does the producer know how to proceed in the event of spill or scatter of plant protection products and do they have tools to counteract such a threat?	❑/❑	
8.	Does the producer restrict access to the keys and the warehouse in which the plant protection products are stored, to persons who do not have the authority to use them?	❑/❑	
9.	Does the producer store on the farm only plant protection products allowed for use with the plant species they cultivate?	❑/❑	
10.	Is the water used to prepare the spray liquid of the correct quality, including the correct pH?	❑/❑	
11.	Are wetting agents or adjuvants added to the spray liquid to improve the effectiveness of treatments?	❑/❑	
12.	Does the producer improve their knowledge at Integrated Plant Production meetings, courses or conferences?	❑/❑	
	Total points		

XIII. ANNEXES

Annex 1

Principles for the prevention and control of diseases in the integrated production of Savoy cabbage

Name of disease	Type and length of protection	Remarks
Protective measures before sowing		
Various fungal diseases, transmitted by soil	- Comprehensive disinfection of soil and horticultural soil on heaps - Decontamination of compost soil and seedbed soil in autumn or early spring.	Use in autumn or early spring at a time that is safe for plants. Use in accordance with the instructions on the label.
Various fungal diseases, transmitted by seeds and soil, causing seedling blight.	Treatment of seeds with fungicides registered for IP.	• For sowing, choosing seed of at least the standard category. • Seeds are to be sown in peat substrates free from pathogens.
Protection of seedlings		
Downy mildew	Spraying seedlings in frames or on seedbeds with fungicides approved for integrated production.	The first treatment should be performed preventively or when the first symptoms appear.
Clubroot		In case of threat from *Plasmodiophora brassicae*, it is necessary to perform a soil analysis for the presence of the pathogen in a specialised laboratory. After finding the pathogen in the soil, do not grow plants of the Brassica family on a given field.
Post-planting protection in the field		

Black spot (alternariosis)	Spraying plants after the onset of the first symptoms of the disease, usually from mid July. After a threat of disease or after the first disease symptoms have been identified, using fungicides with different mechanisms of action, registered for IP.	Sowing seeds of at least standard category, in peat substrates free from pathogens.
Grey mould	Spraying crops 2-3 times every 7–10 days. Starting pre-harvest protection one month before harvesting. The last treatment should be performed no later than 3 days before harvesting. After a threat of disease or after the first disease symptoms have been identified, using fungicides with different mechanisms of action, registered for IP.	Sowing seeds of at least standard category, in peat substrates free from pathogens.
Bacterioses of Brassica vegetables	Avoiding frequent irrigation of crops at high temperatures, mainly at night. Use plant protection products authorised for IP. Remove plants with disease symptoms.	Sowing seeds of at least standard category, in peat substrates free from pathogens.

Annex 2

Threat thresholds for pests on Savoy cabbage

Pest species	Risk threshold	Time of inspection and controlling	Harmful stage
Cabbage fly	1) Scent trap: catching more than 2 flies per day for 2 consecutive days or 2) more than 10 eggs on 10 consecutive plants	The first generation: April, treatment after 2-3 days. Second and third generation: from mid July and August, treatment after 2-3 days	Larva
Fleas	From 2 to 4 beetles per 1 m^2 of cultivation	Emergence period up to the 4-6 leaf stage	Adult insect
Cabbage aphid	60 aphids on 10 consecutive plants	Formation of the first colonies by winged aphids	Adult, larva
Rape seed weevil	2 to 4 beetles in the heart leaves on 25 consecutive plants	Before forming the heads	Adult, larva
Diamondback moth	From 5 to 10 caterpillars on 50 consecutive plants	Beginning of head forming	Caterpillar
Cabbage white	3 to 4 eggs or 10 caterpillars on 10 consecutive plants	July-September	Caterpillar
Small white	1 to 3 caterpillars on 10 consecutive plants	July-September	Caterpillar

Threat thresholds for harmful insects are provided according to Szwejda J. 2015

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