CHIEF INSPECTORATE OF PLANT HEALTH AND SEED INSPECTION

DRAFT

METHODOLOGY

OF INTEGRATED PRODUCTION OF FIELD PEA (SUGAR PEA AND SHELLING PEA)

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

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Approved by

~~/signed electronically/~~

Collective study of the Institute of Horticulture - National Research Institute in Skierniewice

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I. INTRODUCTION

Integrated production (IP) of plants is a modern food quality system that makes sustainable use of technical and biological progress in the cultivation, fertilisation and protection of plants and pays particular attention to the protection of the environment and human health. Application of integrated plant protection principles, which have been mandatory for all professional users of plant protection products since 1 January 2014, is an essential component of the system. These principles particularly prioritise the use of non-chemical methods which should be complemented by the use of pesticides when the anticipated economic losses caused by pests are higher than the cost of the treatments.

In the process of integrated production, it is very important to support natural biological mechanisms through the rational use of fertilisers, crop aids and plant protection products. Their use in modern agricultural production is necessary and extremely beneficial, but can sometimes cause a threat to the environment. Sustainable soil fertilisation and plant nutrition are designed to create a safe and efficient biosystem. This is equivalent to minimising chemical pollution from agriculture in soils and waters and, above all, in commercial yields while also having a positive impact on crop yield, consumer quality, and biological value. The principles of integrated production are set out in the Code of Good Agricultural Practice (CGAP).

Among other things, application of the IP is a guarantee of production of safe and high-quality food (not exceeding permissible residues of harmful substances), less expenditure on production (application of fertilisers based on the actual demand of plants for nutrients, determined in particular on the basis of soil or plant analysis), 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 on 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 (Journal of Laws of 2023, item 2501) and Regulation of the Minister of Agriculture and Rural Development of 24 June 2013 on the qualifications 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(consolidatex text: Journal of Laws of 2023, item 1397) and Regulation of the Minister of Agriculture and Rural Development of 8 May 2013 on training in plant protection measures (Journal of Laws of 2022, item 824).

The prerequisite for the IP certificate is managing production in compliance with this methodology which was approved by the Chief Inspector of Plant Health and Seed Inspection. The integrated production methodology for field pea covers all issues related to

cultivation, fertilisation, and protection. From soil preparation and sowing, through agrotechnical treatments and protection against pests, to harvesting and preparation of pea for sale. The methodology also takes into account the hygienic and sanitary principles to be followed during harvesting and preparation for sale of crops produced in the Integrated Plant Production system and general rules for issuing certificates in integrated plant production. This methodology has been developed based on the results of our own research and the most recent published data, in accordance with the guidelines of Directive 2009/128/EC of the European Parliament, the International Organization for Biological and Integrated Control (IOBC) and the International Society for Horticultural Science.

II. AGROTECHNICS

Artur Kowalski, M.Sc.

Field pea *Pisum sativum* L. is an annual plant, belonging to the Fabaceae family, originating from the southern part of Europe and the north-western part of Asia. It reached the northern parts of our continent after 800 BC, i.e. still in the Iron Age. Its presence in Poland has been confirmed as early as 500 BC through a number of archaeological finds.

Two botanical varieties of pea are distinguished, differing in the structure of the pod:

- sugar pea - *Pisum sativum* L. var. *saccharatum* Ser (without parchment membrane on the inside of the pod wall),
- shelling pea - *Pisum sativum* L. var. *pachylobum* Beck (having a parchment membrane on the inside of the pod wall).

The difference in structure means that sugar pea pods can be eaten whole, while in the case of shelling pea, only the seeds are suitable for consumption.

Pea has a taproot system, the length of which can be about 1m. In addition, lateral roots grow from the upper part of it. On the roots of this plant and other species of plants in the Fabaceae family, there are characteristic nodules. They are formed through symbiosis with bacteria of the genus *Rhizobium*. Cooperation with these micro-organisms means that pea and other leguminous plants can use atmospheric nitrogen for growth and development. The stem of pea, depending on the variety, can reach from about 25 cm to even 300 cm in length. In view of the above, a distinction is made between dwarf varieties with a stem height of up to 90 cm, medium-high varieties of 90 – 150 cm, and high varieties of 150 – 300 cm. Pea has pinnate leaves, from the angles of which white flowers grow (in some varieties, there are also red-purple flowers). The fruit of pea is a pod that may contain between 3 and 12 seeds. The shape, colour and size of the seeds are varietal characteristics. The seeds retain their germination capacity for about 5 to 7 years. The weight of a thousand seeds varies from 150 to 350 g.

When it comes to nutritional value, pea seeds are a rich source of protein (6-7 %), which contains a number of exogenous amino acids. In addition to protein, they also contain valuable mineral salts, as well as vitamin C, carotene, B vitamins, and vitamin E. Shelling pea

grown in Poland is largely intended for industry, mainly for the production of frozen foods and canned goods. On the other hand, the green mass remaining after harvest is an excellent feed for animals.

2.1. Site and crop rotation

Depending on the variety and the purpose of cultivation, the soil requirements of pea vary. Pea grown for green seeds has a shorter vegetation period and, compared to pea grown for harvesting mature seeds, requires more fertile soil.

The best soils for pea cultivation are sandy loam soils rich in calcium, with a soil pH close to neutral and regulated air-water relations. The soils for growing pea should be fertile with a high content of organic compounds. However, soils that are too dry, as well as cohesive soils and wetlands with high groundwater levels, are not suitable for cultivation. On fertile soils, pea yields well in the second or even third year after manure fertilisation. As for water needs, in the case of pea, they are highest during the period of swelling and germination of seeds, as well as at the beginning of flowering. In the event of water shortages during these periods, uneven emergence, slowed growth, and poorer pod setting may occur. The optimal range of soil moisture for this plant is 60-70 % of the field water capacity (FWC). Pea is among the species with moderate heat requirements. The optimal growth temperature ranges from 13 to 18°C, but young plants can withstand temperature drops down to -7°C. Negative temperatures in the later period can damage flowers and buds. If the temperature is too high (above 18°C), sugars may be converted into starch during ripening, which directly affects the deterioration of the taste of the seeds. Under optimal humidity conditions, pea seeds can germinate already at 2°C.

Root crops on manure and other vegetable and agricultural crops are considered suitable precursors for the cultivation of pea. However, pea should not be grown after oneself or after other plants of the Fabaceae family for sanitary reasons more often than every 4 years.

2.2. Soil cultivation and preparation for sowing

Deep pre-winter ploughing should be carried out in late autumn; shallow ploughing and harrowing should be performed after early-maturing preceding crops have been harvested (in order to destroy weeds). Spring agrotechnical treatments preparing the soil for pea cultivation should include discing, cultivating, and harrowing. During field work, cultivation and seeding units that limit the number of passes of the tractor and minimize soil degradation can also be used.

2.3. Selection of varieties

When choosing varieties, a number of factors should be taken into account, as they differ both morphologically and functionally. Varieties intended for industry shall be characterised by: high yield, resistance to diseases, even maturation (to allow mechanical harvesting) and dark green seeds with a diameter of 6.5 to 9.0 mm. The height of the plants

should be in the range of 40 to 80 cm. However, in order to extend the processing campaign, it is necessary to cultivate varieties with different growing seasons.

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

2.4. Methods and timing of pea cultivation

Sowing pea should be carried out as quickly as possible so that, before the onset of a long day and high temperatures, the plants can produce as much biomass as possible. The appropriate date for sowing (depending on the variety) is considered the end of March or the beginning of April. However, sowing should not be delayed beyond the second decade of April, as sowing after this date significantly reduces yield. Seeds intended for sowing should also be inoculated with a biological preparation containing rhizobial bacteria. Sowing can be carried out using a single or multi-row seeder. However, care should be taken to maintain an appropriate distance between the rows. For low varieties, it should be 15 – 20 cm, whereas for high varieties it should be 20 – 25 cm. In a row, the seeds should be sown every 3-4 cm. The optimal density value is assumed to be 120 - 150 plants per 1 m^2 depending on the variety. For varieties with small and medium-sized seeds, the amount of seed needed to sow 1 ha is 150 – 300 kg, while for coarse-seeded varieties this value is 300 – 400 kg/ha. The depth of sowing depends on the type of soil and is in the range of 2 to 6 cm.

2.5. Fertilisation

Pea is a plant with relatively low nutrient requirements and is quite sensitive to soil acidification. In order to correctly determine fertiliser doses, soil analysis for nutrient content and soil pH should be performed first. Too low soil pH negatively affects both the uptake of nutrients by plants and the development of the soil microbiome, which in the case of pea is of particular importance due to its symbiosis with nodule bacteria. Low pH also affects the activation of aluminium ions, which have toxic effects on plants. The optimal pH value for soil cultivation of pea is between 6.5 and 7.8. In the case of excessive soil acidification, liming should be applied in the autumn. Optimal content of the most important macronutrients for pea cultivation, expressed in mg/dm^3 of soil, is: N (25 - 40), P (40 - 60), K (125 - 175). Nitrogen fertilisation should be applied in spring before seed sowing, while phosphorus and potassium fertilisers can be applied in the autumn of the year preceding the crop or in spring together with nitrogen fertilisation. In the case of pea, top dressing with nitrogen shall not be applied. As for the form of potassium fertilisers, both the chloride and sulfate forms can be used. Organic fertilisation also plays an important role in integrated vegetable production. In addition to nutrients, it introduces a large amount of organic matter into the soil, which positively affects the development of the soil microbiome and improves soil structure. Organic fertilisers, through the process of mineralization, provide plants with access to nutrients throughout the growing season. The use of organic fertilisation also allows for the reduction of mineral fertiliser doses.

Increasing the nutrient content of the soil must be based on the results of chemical analyses of the substrate both before and during cultivation.

2.6. Care treatments

In the cultivation of pea, care treatments are mainly limited to removing the crust before emergence using light harrows, irrigation, and weed control. As for weed control, the work should be carried out in the year preceding cultivation through autumn soil cultivation. Autumn weed destruction is very important, as during cultivation, mechanical weed control is very difficult or even impossible due to the high density of pea plants. If there is a water deficit during flowering and pod setting, irrigation is a beneficial treatment. This treatment delays the ripening of pea by 1-7 days.

2.7. Pea harvest

Sugar pea should be harvested when the pods are fully grown and the seeds are in the embryonic stage. The delay in harvesting causes the pods to harden and diminishes their taste. In the case of shelling pea, the harvest should be delayed until the pods are fully grown and the seeds have developed. Choosing the right moment of harvesting is very important, because if the seeds are young and soft, they will be crushed during threshing, whereas if the harvest is excessively delayed, the seeds will contain a lot of starch and will be distasteful. The optimal date for harvesting green pea can be determined by using special devices that determine the firmness of the seeds. The tenderometer determines the force (in JT units) necessary to crush the seeds of pea. For pea intended for freezing, the JT value should be in the range of 95 – 100, whereas for pea intended for canning it is 110 – 125. If it is not possible for the manufacturer to use such devices, the harvest is started when the lowest 1–2 pods already show signs of ageing, while there are still a few ungrown pods at the top. For early varieties, the harvesting date is usually in June, whereas for late varieties, it is in July. Self-propelled mowers or combine harvesters are used to harvest pea for industrial purposes. The period from the moment of mowing pea to the beginning of their processing should not be longer than 6 hours. Pea intended for direct consumption is harvested several times (at intervals of 2 - 4 days) as it reaches maturity.

III. PROTECTION AGAINST HARMFUL ORGANISMS

Harmful organisms, i.e. pests (pathogens, pests, weeds) always occur, even in fields in very good condition and carefully prepared for sowing or planting, which is why protection against them is an important element of integrated vegetable production. Integrated production is a modern and developing cultivation system that takes into account the expectations of customers in relation not only to attractive-looking fruits, vegetables, and other agricultural products, but also to products of high quality. It allows for the production of crops with the highest biological and nutritional values, which are safe for human health. Plant products are strictly controlled for residues of plant protection products, fertilisers, and other substances dangerous to health. Without effective regulation of the level of threat from pests, it is difficult to obtain a high yield of good quality, while maintaining the profitability of production. The intensification of agricultural production poses a significant threat to the surrounding nature, which is why environmental protection is an important

issue. Integrated production takes into account ecological objectives such as the protection of the agricultural landscape and biodiversity.

The basic element of integrated production is integrated pest management, the principles of which are regulated by the following legal acts: Directive 2009/128/EC of the European Parliament and of the Council establishing a framework for Community action to achieve the sustainable use of pesticides (OJ EU L 309, 24.11.2009); Regulation (EC) No 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC (OJ EU L 309, 24.11.2009); The basic Polish legal act in the field of plant protection is the Plant Protection Products Act of 8 March 2013 (consolidated text: Journal of Laws of 2024, item 630).

The general principles of integrated plant protection include: 1. preventing the occurrence and multiplication of harmful organisms or reducing their negative impact; 2. monitoring the occurrence of harmful organisms and, on the basis of these observations, making decisions on the implementation of plant protection treatments; 3. combating harmful organisms. In integrated production, the potential pest risk should be reduced as much as possible, using mainly agrotechnical, biological, mechanical, and physical methods, with the chemical method serving as a complement.

Prevention plays a very important role in counteracting harmful organisms and eliminating their negative effects. Care should be taken to create optimal growth conditions for crops and maintain them in good condition, as only such plants are more resistant to pests. This can be achieved through appropriate crop rotation, proper agrotechnics and careful soil cultivation, the use of resistant or tolerant varieties and healthy seed and planting material, the use of balanced fertilisation and irrigation, the prevention of harmful organisms, the protection and creation of favourable conditions for beneficial organisms, and the application of phytosanitary hygiene rules.

Mechanical soil cultivation plays a significant role in the control of certain pests and reduces the number of viable weed seeds. All cultivation operations prior to planting should be carried out carefully, taking into account the current state of the field and in a timely manner. Appropriate planting dates, row spacings, and plant densities should be chosen so that protection by non-chemical methods is possible and the use of chemicals can be kept to a minimum.

The list of plant protection products approved for sale and use in Poland is published in the register of authorised plant protection products. Information on the scope of application of pesticides in individual crops is included on the labels. The plant protection product search engine is a helpful tool when selecting pesticides. Current information on plant protection products use is available on the Ministry of Agriculture and Rural Development website at
https://www.gov.pl/web/rolnictwo/etykiety-srodkow-ochrony-roslin and
https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin.

The list of plant protection products authorised for integrated production is drawn up by the Institute of Horticulture – National Research Institute in Skierniewice and published in the Plant Protection Programme. The list of authorised plant protection products is also available on the website of the Institute of Horticulture – National Research Institute in Skierniewice at: http://www.inhort.pl/serwis-ochrony-roslin and published on the Pest Alerting Platform at: https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.

In the Plant Protection Recommendations issued by the Institute of Plant Protection – National Research Institute in Poznań, the measures recommended for integrated production are marked with the letters IP.

Only products authorised in Poland for marketing and use, which clearly indicate on the labels attached to the packaging that they are recommended for the crops we protect, may be used for protection against pests. Plant protection products should be used in accordance with the recommendations given on the label. Treatments should be performed under optimal conditions for the operation of the applied agents in order to make maximum use of their biological activity, while minimising doses and at the same time avoiding threats to human health, animals, or environmental pollution. **Plant protection products with different mechanisms of action should be used alternately (where possible) to prevent the development of pest resistance to pesticides.**

For ecological and economic reasons, the number of treatments should be limited to the minimum necessary and plant protection products should be used in the lowest possible doses, ensuring sufficient effectiveness. This reduces pressure on the natural environment and protects the biodiversity of the agricultural environment. **Principles of integrated plant protection must be respected and preference should be given to any non-chemical means of reducing and eradicating pests and pathogens. At least one of the plant protection treatments should be carried out using a non-chemical preparation.** Reducing the use of plant protection products can be achieved by: reducing doses, using the split method, reducing the number of treatments by adjusting the timing of treatments to the developmental phases of the pests when they are most sensitive, adding adjuvants to the spray liquid, selecting appropriate and technically efficient spraying equipment, and adjusting the amount of water used for the treatment, depending on the pests to be controlled.

One way to reduce the use of plant protection products may be to apply them precisely in locations where a specific harmful organism is present. When combating some pests, it is not always necessary to spray the entire plantation with an insecticide. Sometimes, based on accurate diagnosis, it is sufficient to perform the procedure on the outskirts or selected fragments of the field. Some species of weeds (e.g. couch grass) may not grow in a uniform way on the entire surface of the field but in the form of patches. In this case, spraying can be limited only to their places of occurrence.

Pests do not necessarily occur annually and on every plantation, so not all species require equal control. The basic principles of Good Plant Protection Practice include the

application of measures on the basis of the correct identification of pests and their current prevalence, taking into account the available thresholds for economic harm, rather than according to a predetermined programme. It is therefore vital to systematically monitor pea crops for the presence of harmful organisms, determining their severity and area of occurrence, as well as forecasting the occurrence of weeds. Various types of traps are currently used to catch insects, utilizing the insects' ability to respond to light wavelengths and various odours. Knowledge of monitoring methods, as well as the ability to identify pests or damage to plants caused by them, is necessary for alerting. In the event of difficulties in diagnosing pests, it is necessary to contact specialists who, in addition to identifying the harmful organism, may also recommend an appropriate method to combat it.

Not all plant protection products intended for use in the cultivation of a specific plant species should be used in integrated production. First of all, it is necessary to use those agents that have the shortest withdrawal period and have the least negative effect on beneficial organisms. To perform the procedure, it is necessary to choose agents that may cause the least possible side effects on human health and the environment, and to use them in a way that reduces the risk of resistance in harmful organisms. For reasons of environmental protection and the need to preserve biodiversity on the plantation, the annual use of the same active substances and chemical groups should be avoided, as this may result in weed compensation or the emergence of biotypes resistant to these chemical substances.

The effect of plant protection products on harmful organisms depends not only on their composition or crop and its development phase, but also on soil and climatic conditions. Some products may be used for prevention (e.g. fungicides) or intervention (pesticides and herbicides). Herbicides should be used only in phases of the highest sensitivity of weeds and in doses carefully adjusted to the soil conditions. Better efficiency and more economical consumption of some products can be obtained by adding adjuvants to the liquid. These additives reduce the surface tension of the spray liquid, increase the adhesion of agents, improve penetration into the plant, and limit leaf washing. Herbicides generally work more strongly the higher the temperature, while some insecticides may act adversely or cause damage to the sprayed plants. It is recommended to spray the plantations during rainless and preferably windless weather, when the air temperature is 10 – 20°C. If the temperature is higher, treatments must be carried out in the early morning (when the plants are in full turgor) or in the afternoon.

Treatments are best done with sprayers that provide exact coverage of the sprayed surface with utility liquid droplets equipped with low-pressure, flat fan atomisers. As a rule, it should be assumed that vortex atomisers should not be used on standard field beams due to the impossibility of obtaining an even distribution of liquid. This is due to the conical shape of the spray jet and the narrow spraying angle.

The spray liquid must be prepared in a quantity not greater than that specified on the label for use on the sprayed surface. Empty packages must be rinsed three times with water and the rinsing water poured into the spray tank. The most commonly recommended

amount of liquid using conventional sprayers is 200 - 300 l/ha for soil herbicides and 150 - 250 l/ha for foliar herbicides, and using the AAS technique (auxiliary air stream) 100 - 150 and 75 - 150 l/ha respectively. For the application of fungicides and insecticides, conventional equipment should be used at 200 - 400 l/ha when spraying plants up to a height of 25 cm or until row closure, and 400 - 600 (800) l/ha when spraying taller plants or after row closure, and with PSP at 100 - 150 and 150 - 200 (400) l/ha respectively. One should also pay attention to the detailed recommendations contained in the product label, which must be followed.

The speed of the sprayer should be determined by the wind speed during the treatment. For a sprayer without an auxiliary air stream, the speed of its movement shall not exceed 4–5 km/h at a wind speed of more than 2 m/s; while during favourable weather (wind up to 2 m/s) – 6-7 km/h. Sprayer with sleeve and AAS can move at a speed of 10 - 12 km/h.

After treatment, the sprayer should be thoroughly washed, preferably with special agents designed for this purpose, made on the basis of sodium phosphates or hypochlorite. Washing the sprayer should be carried out on a pre-prepared Biobed or the rinsate should be collected and poured into the sprayer tank, and then used on the treated surface. During work in the storeroom of materials, during the preparation of the spray liquid, performing treatments, and washing the sprayer, it is absolutely necessary to comply with health and safety regulations and use appropriate protective clothing.

Plant protection products differ in their length of action and persistence in the environment. This should be taken into account when planning follow-up crops or for screening, when the plantation (e.g. destruction by diseases or pests) shall require earlier liquidation for any reasons.

It is important to comply with the rules of phytosanitary hygiene. Attention should be paid to the careful collection of plant debris after the end of the season, as they can be a place for wintering harmful organisms. This applies to both field crops and those grown under cover. It is important to establish a crop from healthy seedlings, not infested by pathogens and pests. Some pests can inhabit plants very early at the stage of emergence and during the production of seedlings, with which they are then brought to the place of cultivation. Systematic cleaning of vehicles, machines, and tools used for plant care during cultivation prevents the transmission and further spread of pests.

Plant protection products should be used according to the indications on the label and in such a way as not to endanger human health, animals or the environment.

IV. Occurrence and harmfulness of weeds in pea cultivation

Dr Zbigniew Anyszka, *Dr Joanna Golian*

In the cultivation of pea, weeds are common, regardless of habitat conditions; only their abundance and growth intensity change on plantations. Pea is moderately susceptible to weeds, due to the short period of emergence, rapid growth in the initial growing season, good covering of the inter-rows by the leaves, and the short growing season. The sowing period for pea is from the third decade of March to the first decade of April, i.e, during the period of intense weed emergence with lower thermal requirements. Emerging weeds strongly compete with the crop, as they grow quickly and make better use of water and nutrients taken from the soil, which can cause a decrease in yield and deterioration of its quality, especially if they occur in high intensity. Abandoning weeding can reduce the yield of pea by up to half. Pea seeds are sown at a density of 80-100 pcs./m^2, with row spacing every 10-25 cm. When planning mechanical weed control during cultivation, this spacing should be increased to 30 cm. The intended use of the crop and the associated length of the growing season are also important. Pea (grown for green pods) is harvested earlier than pea grown for seeds, which is why it is less affected by weeds. In seed cultivation, the period of weed competition is longer and the impact of weeds on pea can be stronger. Preventing secondary weed infestation, which significantly hinders mechanical harvesting, is of crucial importance here. Regardless of their purpose, preventive treatments play an important role in pea. Pea reacts most strongly to weeds in the period from emergence to the beginning of shoot elongation. In later periods, until the phase when 10 % of the pods reach the appropriate length, only monocot weeds are destroyed using the foliar route.

In pea crops, we are dealing with primary weed infestation, occurring in the initial growing season, and secondary weed infestation, occurring before the harvest. Primary weed infestation is the most dangerous, as weeds occurring during this period strongly affect the development and growth of pea, and thus the yield and their quality. Weeds occurring in the second half of the vegetation period hinder mechanical harvesting and extend the harvest date; moreover, they contribute to the deterioration of phytosanitary conditions on the plantation and complicate the application of plant protection products.

Segetal weeds (cropland weeds) can be divided into proper and facultative, also referred to as relative weeds, which include self-seeding crops (rapeseed, horseradish, dill, etc.). The most serious losses in the crop of pea are caused by weeds occurring in the period from sowing to covering the rows through the leaves during the so-called critical competition period. Delaying the first weed control action by 2 weeks can result in a reduction in the crop of pods by about 20 %. The threat to pea increases during drought, since weeds consume substantial amounts of water and shade the soil which contributes to the lowering of its temperature and delayed harvesting. Strong weed infestation may cause symptoms of nutrient deficiencies. The plants are lighter, smaller, they can be more fragile, and the crops are reduced and of inferior quality. The structure of the weed population during the pea

sowing period differs from the structure of the population observed in other vegetable species sown at a later time.

In pea cropsmonocot and dicot weeds may occur, both annual and perennial, and the dynamics of their appearance and species composition depend, among other factors, on their biological properties, the cultivation area, the seed stock in the soil, habitat conditions, and weather 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).

In pea crops, weed species germinating at low temperatures appear (daily average 1-5°C), such as: white goosefoot, field mustard, common chickweed, shepherd's purse, annual nettle, field pennycress, buck-bindweed, false mayweed, common henbit, bindweed knotweed, mayweed-like weeds, wild radish, common groundsel, and later also species germinating at higher temperatures such as potato weed, small-flower and hairy galinsoga, and redroot pigweed. Weeds with low thermal requirements usually appear together with the emergence of pea. Among the monocot weeds in pea cultivation, the most common are cockspur grass, wild oat, and couch grass, sometimes foxtail. Pea is less frequently found with: field pensy, Persian speedwell, common fumitory, small-flowered crane's-bill. The harmfulness of weeds, presented in Table 1, depends, among other factors, on their biological characteristics (height, form), intensity of occurrence, and the course of weather conditions. Many species of weeds are characterised by a broad ecological optimum, i.e. they can appear at different periods of the growing season, regardless of weather conditions. These include, but are not limited to: white goosefoot, small-flower galinsoga, shepherd's purse, field mustard, field pennycress, field pansy, Persian speedwell. They are an essential component of secondary weed infestation which makes it difficult to perform treatments against diseases and pests, delays maturation, worsens the quality of crops, and hinders harvesting.

NOTE! Proper protection against weeds requires knowing weed species and methods of their control. **It is the responsibility of every IP producer** to **identify the weed species present in the field** intended for the cultivation of pea and to record their names in the integrated production notebook. Observations should be conducted in the year preceding the cultivation of pea. For the proper identification of weed species, the Integrated Protection Methodology of pea 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 at: https://www.inhort.pl/serwis-ochrony-roslin/metodyki-rosliny-warzywne/. In order to facilitate protection of subsequent crops, weed species should also be identified during the cultivation of pea and their names should be recorded in a notebook.

Table 1. Harmfulness of the more important weed species in pea cultivation (alphabetical list)

Species – English and Latin name	Harmfulness
1. Dicot weeds	
Crane's-bill (*Geranium* spp.)	+
Cornflower (*Centaurea cyanus* L.)	+
Common fumitory (*Fumaria officinalis* L.)	+
Field pansy (*Viola arvensis* Murr.)	++
Field mustard (*Sinapis arvensis* L.)	++
Common chickweed (*Stellaria media* (L.) Vill.)	+++
Common stork's-bill (*Erodium cicutarium* (L.) L'Hér.)	++
Common henbit (*Lamium amplexicaule* L.)	++
White goosefoot (*Chenopodium album* L.)	+++
False mayweed (*Matricaria maritima* L. subsp. *inodora* (L.), Dostál)	++
Annual nettle (*Urtica urens* L.)	+
Field pansy (*Veronica* spp.)	++
Catchweed (*Galium aparine* L.)	++
Buck-bindweed (*Fallopia convolvulus* (L.) Á. Löve)	++
Field chamomile (*Anthemis arvensis* L.)	+++
Chamomile (*Chamomilla recutita* (L.) Rauschert)	++
Groundsel (*Senecio vulgaris* L.)	++
Redroot pigweed (*Amaranthus retroflexus* L.)	+
Shepherd's purse (*Capsella bursa-pastoris* (L.) Medik.)	+++
Field pennycress (*Thlaspi arvense* L.)	++
Small-flower galinsoga (*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.)	+++
Foxtail (*Setaria* ssp.)	++

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

4.1. Non-chemical methods of weed control

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

Prevention and agrotechnical methods

These include, among other things: selection of an appropriate plant for cultivation, appropriate crop rotation to prevent weed compensation, selection of varieties adapted to

local soil and climate conditions, careful soil cultivation, fertilisation based on analyses of fertilising needs of arable crop and soil abundance, appropriate sowing date and appropriate density of plants, careful care during cultivation, including irrigation during periods of water scarcity, preventing blooming and release of seeds by weeds.

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

Mechanical methods of weed control

Mechanical treatments performed in the period before sowing pea are used to create the appropriate soil structure, destroy weed seedlings, and reduce the content of their seeds in the soil, while those performed during the cultivation of pea make it possible to keep weeds at a low level. Mechanical weeding of pea during cultivation is currently rarely used; however, due to changes in the weeding strategy, which involve reducing the use of herbicides and the number of chemical treatments, as well as the greening of crops, it is necessary to consider the increasing need to use this method of weeding. In addition, there are weeders with modern technical solutions that allow for the quick and effective destruction of weeds, even in rows of plants, as well as reducing the cost of treatments.

Mechanical treatments can be performed after sowing, before the emergence of pea (BBCH 00-07), using a light spring-toothed harrow, or after the emergence of the pea. Do not harrow pea during the emergence period. During the germination period, pea is sensitive to weed infestation and mechanical damage, as well as to soil crusting, because it germinates hypogeically, i.e. the cotyledons remain under the soil surface, and a delicate epicotyl stem penetrates above the surface, which quickly lengthens. After sowing, the weed harrow is most often used. Weeding with a light harrow is possible from sowing until the period when the pea's hypocotyl is below the soil surface and the working elements of the weeding tools do not come into contact with it. Mechanical treatments after the emergence of pea, such as using a weed harrow, can be performed from the 2-3 leaf stage (BBCH 12-13), when the plants are approximately 5 cm high (when rows of plants are clearly visible) and after the appearance of weed seedlings (preferably from the cotyledon stage to 2-4 leaves), with subsequent treatments depending on the re-emergence of weeds, until the inter-rows are closed by the leaves of the pea. After the inter-rows are covered by the leaves of pea, weeds should be removed only manually. Harrowing with a weeder should be performed diagonally or across the rows, as this allows the teeth of the harrow to remove weeds between the plants in a row.

If mechanical weeding is planned in pea cultivation, the spacing of the pea rows should be adapted to the track width of the tractor and tools used for mechanical treatments and should preferably be 30-35 cm. Manual and mechanical weeding can be performed after the

appearance of weeds, preferably after rain or irrigation and once the soil has dried. The number of mechanical treatments, without the use of herbicides, depends on the dynamics of the appearance of weeds and weather conditions. In pea, there is usually a need to perform 1-2 mechanical treatments, supplemented by hand weeding. Mechanical treatments are best carried out after rain or irrigation and once the soil has dried, preferably in the afternoon when plant tissues exhibit reduced turgor. They should be carried out as shallowly as possible, to the same depth (usually 2-3 cm), when weeds are small and less rooted. With low weed infestation, this treatment can be omitted, as its implementation stimulates weeds to regrow. Treatments performed too deeply are energy-intensive, can damage the root system of pea, and cause the displacement of weed seeds capable of germination to the upper layer of the soil.

Harrowing is best carried out in conditions of less moisture in plant tissues, when the top layer of the soil is dry. The procedure is best performed before the period of warm and sunny weather, as the seedlings uprooted by the weeder's tooth are quickly dried. Harrowing should not be carried out on overly moist ground, as it can lead to soil crusting and disturbance of water-air relations, nor on dry soil, as it will lead to dusting of the ground. After herbicide application, mechanical and manual treatments should only be carried out if the weeds are not effectively destroyed. The labour input in such a protection scheme is much smaller than with cultivation without the application of herbicides.

Mechanical weeding, in addition to reducing or completely eliminating plant protection products, also offers other benefits, including loosening and aerating the soil, eliminating soil crust, improving the penetration of rainwater into the soil, protecting groundwater by breaking capillaries, and reducing the number of pests and transmitted diseases.

Thermal weed control

Weeds can also be controlled with flame (gas) weeders. Such a procedure may be performed on the entire field or in places intended for rows of plants, directly before pea emergence and following weed emergence. It is also possible to burn weeds in inter-rows, during cultivation, preferably with burners equipped with shields to protect plants from high temperatures, but then a complementary manual weeding should be performed. Weeds treated with high temperature die quickly (up to a few days), however, this treatment does not protect against the emergence of the next weeds. It is assumed that flame weeding delays the next weeding procedure by approximately two, sometimes up to three weeks. Weed burning is quite expensive and it is recommended mainly for organic crops. Mechanical procedures are more cost-effective.

4.2. Chemical protection against weeds

To prevent the occurrence of weeds, good agricultural practices should be observed during the entire crop rotation and weed control procedures ought to be performed. Perennial weeds present in the field intended for pea cultivation can be destroyed after the harvest of the preceding crop or in spring, using systemic non-selective herbicides. Its

application in autumn offers better results, and the herbicide can be used until late autumn if the temperature is not too low. After the application of these agents in the spring, it is best to start cultivation treatments 2-3 weeks after the application, and if necessary, at the earliest 5-7 days after the application, when the weeds show signs of the agent (withering, yellowing). At the time of treatment, weeds should be in a period of intensive growth. To increase their efficiency, a corresponding adjuvant may be added to the spray liquid.

Rules for the selection and use of herbicides in pea cultivation

The use of herbicides cannot pose a risk to the health of humans and animals or to the environment. The choice of means and their doses should depend on the weeds present and their severity, as well as the timing of the procedure and environmental conditions. In the cultivation of edible pea and pea for dry seeds, weeds can be controlled with soil-applied herbicides, used after sowing pea, and with foliar herbicides, applied after its emergence. Chemical protection of pea against weeds should be based mainly on soil herbicides, as they allow for maintaining a field free from weeds during the so-called critical period of weed competition, i.e, during the time of the highest sensitivity of pea to weeds, which occurs during the emergence of pea and immediately thereafter. 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.

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

The optimal treatment temperature for most herbicides is in the range of 10-20°C. For some, it is higher, e.g. graminicides should not be used at a temperature above 27°C. At higher temperatures, the agents used can damage pea. When using graminicides, particular attention should be paid to the length of withdrawal periods in order to prevent the occurrence of residues of these agents in the consumer parts of pea, especially in varieties with a shorter growing season.

Herbicides should be used during dry weather. A small amount of precipitation after the use of soil-applied herbicides is favourable, while heavy rainfall may lead to flows of the product in soil and even crop damage. Following a foliar application, precipitation may wash the product off the leaves and weaken its activity. The required period between the treatment and precipitation varies for different products, and its length is often specified on product labels. The effectiveness of the agents (and the reduction of the use of the agent)

can be improved by the addition of adjuvants (boosters) to the spray liquid of certain foliar herbicides.

The period when the herbicide is active and remains in the environment should be considered when planning crop rotation and follow-up crops. In pea, among others, products with a longer period of deposition in the soil are recommended following which follow-up plants should be chosen accordingly.

Plant protection products shall be used in accordance with the instructions given on the label-instructions for use of the product in such a way as to avoid any risk to human health, animals, or environmental.

Chemical protection of pea against weeds should be based on herbicides used after sowing pea. Foliar treatments should be performed on the basis of the actual level of threat to the crop posed by weeds. Sometimes even a small number of weeds can cause the same reduction in crops as with other species at greater intensity. The decision to perform the herbicide treatment should be guided by the 'required weed-free period' or the 'critical weed competition period', i.e. the time period when weeds from an economic point of view cause the greatest losses in crops. The required weed-free period for pea is from emergence to row closure. During this period, care should be taken to assure as little weed as possible; weeds must not be allowed to produce seeds.

The current list of herbicides registered for protection of pea from weeds can be found in vegetable protection programmes published in industry journals and on the website of the Ministry of Agriculture and Rural Development (www.minrol.gov.pl).

The list of plant protection products authorised for integrated production is drawn up by the Institute of Horticulture – National Research Institute in Skierniewice and published in the Vegetable Plant Protection Programme and on the website of the Institute of Horticulture – National Research Institute (https://www.inhort.pl/files/sor/wykaz_srodkow_ip/Wykaz_fungicydow_do_IP_w_uprawach_warzyw_gruntowych.pdf) and the Pest Alerting Platform (https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji).

Crop rotation after herbicide use

Herbicides vary in duration of action and persistence in the soil which should be taken into account when planning follow-up crops. On herbicide usage labels there are listed species of plants which may be cultivated in the year when a herbicide was applied, after a complete cycle of cultivation of pre-crop plant. Most agents do not pose a threat to post-crops, yet some are retained longer in the soil and may cause the emergence of symptoms

of phytotoxicity in plants cultivated as post-crops. Before starting cultivation, please refer to the information on the follow-up effects of herbicides given on the product labels. For the cultivation of pea, it is necessary to choose sites following plants where herbicides with a short period of deposition in the soil were used. When herbicide mixtures are applied, follow the crop rotation recommendations for the products in the mixture. If the pre-crop plants treated with herbicides are to be removed early, plants for which those herbicides are recommended or species that do not show negative reactions to the active ingredient of the agent used, most often listed on the label of the product used, should be grown. The cultivation of post-crops should be preceded by medium or deep ploughing.

V. INFECTIOUS DISEASES

5.1. Bacterial diseases

Prof. Joanna Puławska

Bacterial blight of pea – pathogens: *Pseudomonas syringae* pv. *pisi* (Sackett) Young, Dye & Wilkie; *P. syringae* pv. *syringae* van Hall

The disease initially manifests itself in the form of small, dark green, water-soaked lesions on leaves and bracts. The lesions may enlarge and merge, but they are always limited by the nerves of the leaves and have a characteristic fan shape. Changes on the leaves become yellowish, later brown, and changes on the pods are sunken and become olive brown. Damage can also develop on the stems near ground level. They start with areas soaked in water, which later turn olive green to dark brown. Changes on the shoots can merge, causing the shoot to wilt and die. Infection of the stem can spread upwards, reaching the bracts and leaves, leading to the complete death of plants. Both bacteria can survive on seeds or remnants of pea plants, while *P. syringae* pv. *syringae* can survive on a variety of host plants. The disease usually spreads in the field by sowing infected seeds. During rainy weather, bacteria spread from infected plants to healthy ones through rain splashes, water droplets carried by the wind, and contact between plants. Infection can occur at any stage of plant growth, and most often occurs after frosts. Plants damaged by frost or other mechanical damage are more susceptible to infections. Rainfall, abundant dew, strong winds and low temperatures create the most favourable conditions for the spread of pathogenic bacteria in crops.

<u>Prevention and control</u>

Healthy seeds should be used. Seeds from crops on which bacterial blight has been found during field inspections shall not be used. Field inspection should be carried out at the halfway point or at the end of pod filling. Bacteria can survive on seeds for at least 2 years. To obtain a disease-free crop, do not sow pea on land sown last year with pea or in the vicinity of pea stubble. If possible, pea should not be grown on the same site more than once

every three years. If the disease occurs, the break in cultivation on the same site should be extended to four years.

5.2. Fungal diseases

Dr Anna Jarecka-Boncela, Dr Magdalena Ptaszek, Dr Agnieszka Włodarek

Pea seedling blight – pathogens: *Rhizoctonia solani* Kühn, *Botrytis cinerea* Persoon, fungi of the genus *Fusarium* and fungus-like organisms of the genus *Pythium*

The agents of seedling blight can inhabit seeds or develop in the substrate from which they infect the roots and shoots of seedlings. Symptoms of seedling blight include constrictions at the base of the stem, which lead t o plant death. Infested roots turn brown and die off. Fungi causing pea blight overwinter in the soil in the form of survival spores – sclerotia, which enable them to persist in the substrate for several years. Due to the diversity of the pathogens causing seedling blight, it is necessary to take into account the variability in the species composition of fungi and fungus-like organisms depending on different weather conditions, which are optimal for their development. A temperature of 25°C promotes the development of fungi of the genus *Fusarium* and *R. solani*. However, at low temperatures, fungal-like organisms of the genus *Pythium* develop very well.

Prevention and control

In order to reduce the occurrence of seedling blight, soil crusting should be avoided by maintaining proper water-air relations. Appropriate crop rotation should also be observed. Healthy seed should be used for sowing.

Ascochyta blight of pea – pathogens: *Mycosphaerella pinodes* (Berk. & A. Bloxam) Vestergren syn. *Peyronellaea pinodes* (Berk. & A. Bloxam) Aveskamp,Gruyter & Verkley, *Phoma pinodella* (Jones) Morgan-Jones & Burch, *Ascochyta pisi* Lib.

These pathogens are widely known in pea growing areas around the world. In Poland, they are recorded on many species of pea, bean, broad bean, soybeans, nonesuch, and yellow sweet clover. Symptoms of the disease are irregular brown spots with a bright centre and a dark border. They are observed on all organs of the plant (leaves, stems, seeds, and pods). The development of pathogens is favoured by high air humidity and temperature. On infested plants, pycnidia with conidial spores are formed. These spores infect neighbouring plants, becoming a source of secondary infection. Fungi overwinter in the form of mycelium on seeds and crop residues. The disease spreads mainly through infested seeds.

Prevention and control

Healthy seed must be used for sowing. Thoroughly remove crop residues from the field. After harvesting plants from the field, deep ploughing should be carried out to destroy wintering forms of pathogens. Do not allow over-fertilisation with nitrogen, which stimulates the increase in the severity of symptoms.

Fusarium wilt of pea – pathogens: *Fusarium oxysporum* f. sp. *pisi* (Linford) Snyder & Hansen, *Fusarium solani* f. sp. *pisi* (Jones) Snyder & Hansen

Fungi of the genus *Fusarium* are micro-organisms commonly inhabiting the soil, causing fusarium wilt of pea and beans. They infect plants at all stages of their development. Depending on the species of pathogen, we distinguish between vascular fusariosis and gangrenous fusariosis. The first symptoms of vascular fusariosis appear at the end of June, manifesting as wilting of plants; the leaves turn yellow, become flaccid, and fall off. In the cross-section of the shoot, browned conductive bundles are visible, which prevents the plant from transporting water and nutrients. *F. solani* is the cause of root and stem base rot in pea. A symptom observed on overground parts of plants is inhibition of growth. Pathogens overwinter in the form of chlamydospores and mycelium in the soil on plant residues. Optimal temperature for the development of *F. solani* is around 20°C, whereas for vascular fusariosis it is above 25°C. The disease is spread mainly by infested seeds.

Prevention and control

Healthy seed must be used for sowing. Thoroughly remove crop residues from the field. After harvesting plants from the field, deep ploughing should be carried out to destroy wintering forms of pathogens.

Grey mould – pathogen: *Botrytis cinerea* Persoon

This is the most common disease found in the cultivation of many species of vegetables, including pea. The pathogen attacks plants in all phases of development. Symptoms of the disease initially appear as watery spots, which over time acquire a greyish-brown colouration, and are observed on all plant organs. In conditions of high humidity optimal for the development of the pathogen, a grey-beige, abundant, dusty coating of mycelium and conidial spores is observed on the infested tissues. The development of the disease is facilitated by high air humidity (above 95 %), rainfall, cool nights, dew, and the weakening of plants by other pathogens. The pathogen of the disease develops in a temperature range of 5 – 30°C, with an optimum of about 15 – 18°C. The pathogen overwinters in the soil on plant residues in the form of mycelium and sclerotia – survival structures. Infested seeds can also be a source of infection.

Prevention and control

Healthy seed must be used for sowing. Thoroughly remove crop residues from the field. After harvesting plants from the field, deep ploughing should be carried out to destroy wintering forms of pathogens.

Powdery mildew of pea – pathogen: *Erysiphe pisi* (de Candolle) St-Amans

The fungus is commonly found on crops of plants of the Fabaceae family. The first symptoms of the disease usually appear in the second half of the summer. It is a white powdery coating on the leaves composed of mycelium and stalks with conidial spores of the pathogen. Infested leaves die prematurely, and shoots with a coating are inhibited in growth. Infected pods, on the other hand, prematurely turn brown and crack. The

development of the disease is favoured by low air humidity and high temperature. Pathogen spores spread with air currents. The fungus overwinters on plant residues in the form of a cleistothecia. The primary infection is caused by ascopores, and the secondary by conidial spores.

Prevention and control

After harvesting the plants from the field, deep ploughing should be carried out to incorporate the plant residues containing the husks. Do not allow plants to be over-fertilized with nitrogen, which weakens the plants.

Downy mildew of pea – pathogen: *Peronospora viciae* f.sp. *pisi* (Sydow) Boerema & Verhoeven

On the upper side of the leaves, irregular yellow spots are observed, which over time become brown, bordered by veins. On the underside of the leaf blade, there is a grey-violet coating of conidial spores of the pathogen. The source of infection may be oospores produced by the pathogen, mycelium overwintering on crop residues, as well as conidial spores. The development of the disease is facilitated by high air humidity (above 95 %), rainfall, cool nights, and dew. The optimum temperature for pathogen development is around 15–18°C.

Prevention and control

Healthy seed must be used for sowing. Thoroughly remove crop residues from the field. After harvesting the plants from the field, deep ploughing should be carried out to destroy the wintering forms of the pathogen. Do not allow over-fertilisation with nitrogen, which stimulates the increase in the severity of symptoms.

White mould – pathogen: *Sclerotinia sclerotiorum* (Libert) Korf & Dumont

The *S. sclerotiorum* fungus is a polyphage, infecting more than 400 plant species. Symptoms of the disease can be observed on shoots in the form of white or greyish-white spots. As the infection develops, a profuse, fluffy, white mycelium is visible within which black endospore spores (sclerotia) form. The pathogen causes the shoots to die; consequently, the infested plant dies. The disease perpetrator very often colonises fragments of dead tissue and then develops as a pathogen on living plant cells. It develops best in conditions of moderate temperature and high air humidity.

Prevention and control

Healthy seed must be used for sowing. Thoroughly remove crop residues from the field. After harvesting plants from the field, deep ploughing should be carried out to destroy wintering forms of pathogens.

5.3. Methods and dates of monitoring

In order to ensure effective protection against diseases, information about their occurrence, degree of infestation of the plants by their perpetrators as well as an assessment of the potential risks caused by them are necessary. Such information is

provided by a properly performed monitoring carried out on the farm, in a specific area, or in the entire country. **Monitoring** is a regular inspection for the occurrence of harmful organisms (pathogens, pests or weeds) on plantations and the changes taking place in them over a certain time. In order to conduct monitoring, it is necessary to identify the harmful organism that is subject to observation, and select the method and frequency of observation. The appearance of pests at a severity that threatens arable crops is the moment when a decision to perform a procedure with a plant protection product should be taken.

Computer decision support systems developed for different plant species are used in some countries to decide whether a treatment with a plant protection product is necessary. In Poland, there is no such system for field pea. Pest prevention and control in pea crops should be carried out on the basis of pathogen alerting and, for example, the Vegetable Plant Protection Programme, prepared annually by a team of employees of the Institute of Horticulture – National Research Institute, printed in book form, available at: https://www.inhort.pl/serwis-ochrony-roslin/ochrona-roslin-rosliny-warzywne/rosliny-warzywne-programy-ochrony/. Communications on current pest risks also facilitate decision-making. When monitoring pathogens, the Field Pea Alerting Guide can be referred to, which is available on the website of the Institute of Horticulture - National Research Institute in Skierniewice https://www.inhort.pl/sygnalizacja-agrofagow-poradniki-rosliny-warzywne/.

5.3.1. Types of disease prevention

Preventing the occurrence and spread of harmful organisms in pea crops involves the use of **phytosanitary hygiene measures**which include the following cultivation elements:

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

5.4. Non-chemical methods of disease control in pea (sugar and shelling)

Agrotechnology method

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

Growing pea 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. In a rotation that includes the cultivation of Fabaceous crops, there should be a minimum 4-year rotation of crops, as well as intercropping and cultivation of crops other than Fabacea, such as leek, cucumber, spring cereals, grasses. Fabaceous plant varieties resistant to diseases of infectious origin should be preferred. Uncontrolled development of weeds should not be allowed.

Location of plantations. Choosing the right **location** is an important element in the prevention and spread of pests, mainly diseases posing an epidemic threat to pea. To prevent the occurrence of pea diseases, it is necessary to avoid cultivation in areas surrounded by bushes, trees, near water bodies and meadows, where morning fog may cause prolonged leaf wetting. This is the most important factor conducive to infection and the development of most pathogens of fungal, fungus-like, and bacterial origin, e.g. the pathogen of grey mould.

Timely performance of mechanical soil tillage 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 can be transferred on wheels of machinery and growing tools to adjacent fields.

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

Fertilisation. Proper nutrition of pea plants has a significant impact on the condition of plants. Organic fertilisation with manure and compost has a beneficial effect, as beneficial micro-organisms are introduced into the soil, which stabilize the microbial balance. In pea cultivation, an important issue is the assimilation of atmospheric nitrogen through bacteria of the genus *Rhizobium*, symbiotically developing on pea roots. Therefore, it is necessary to control the nitrogen content in the soil, as excess can cause greater sensitivity of plants to pathogens.

Weed control. The presence of weeds in the fields is conducive to the occurrence of certain diseases, mainly white mould. Many species of weeds host the agents of this disease, including some pathogenic bacteria and viruses. Weeding of fields eliminates the source of primary infection of pathogens that can survive on weeds.

Phytosanitary hygiene measures. Accurate removal of crop residues and parts of infested plants is a measure to prevent or reduce the occurrence of many fungal or bacterial pathogens, as they serve as their wintering sites.

Cultivation method

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

Biological method

The biological method is successfully used in many vegetable crops under cover, and less often in field crops. In pea protection, 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.

5.5. Chemical controlof field pea diseases

Preventive method

It involves the use of measures in the form of seed treatment, watering seedlings, and the application of soil granulates before the appearance of pathogens 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 active substances.

Intervention method

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

5.6. Characteristics of the protection measures used in the cultivation of field pea against diseases

Growing pea in an integrated production system does not preclude the use of fungicides to combat diseases of infectious origin. Such agents shall comply with the following conditions: low toxicity to humans and animals, rapid decomposition dynamics and non-

accumulation in the environment, selectivity for beneficial insects, a safe formulation, and a broad spectrum for controlling multiple diseases simultaneously. The withdrawal period is very important. Fungicides used interventionally should have a short withdrawal period when the pea reaches consumer maturity. Often, the same product has different withdrawal periods defined for different vegetable species. **Fungicides in the protection of pea should be used with various mechanisms of action and alternately, to prevent the development of resistance in pathogens to the applied agents.** Up to date information on the use of plant protection products may be found on the website of the Ministry of Agriculture and Rural Development at https://www.gov.pl/web/rolnictwo/ochrona-roslin. The list of plant protection products authorised for integrated production is drawn up by the Institute of Horticulture – National Research Institute in Skierniewice and published in the Vegetable Plant Protection Programme and on the website of the Institute of Horticulture – National Research Institute (https://www.inhort.pl/files/sor/wykaz_srodkow_ip/Wykaz_fungicydow_do_IP_w_uprawach_warzyw_gruntowych.pdf) and the Pest Alerting Platform (https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji).

VI. PESTS

Dr Małgorzata Sekrecka

Knowledge of pest biology, their occurrence dates and harmfulness are the basis for using effective methods of protection. Below are the most common pests found on pea.

FLIES (Diptera) — Anthomyiidae family

Bean seed maggot – *Delia florilega* (Zetterstedt)
Bean seed fly – *Delia platura* (Meigen)
Polyphagic species are found throughout the country. They damage pea grown on soils with undecomposed organic fertiliser.
Type of damage. The larvae initially feed on germinating seeds, then bore into the cotyledons and tunnel through them. They damage the growth apex, which results in the inhibition of plant growth and the death of seedlings.
Pest description. Bean seed flies are up to 6 mm long, while bean seed maggot flies are smaller, up to 4 mm, and are grey with black legs and antennae. Black bristles are visible on the body.
The egg is white, with a length of up to approximately 1.2 mm. The whitish larva grows up to 8 mm in length, and the pupa to about 5 mm.
Biology outline. Larvae overwinter in cocoons in the soil at a depth of up to 5 cm. In April or May, flies emerge and feed on the nectar of flowering plants. Females, after copulation, lay

eggs most often in places where there is freshly incorporated manure, as well as under soil clumps and plant debris. The development of larvae lasts up to 4 weeks, followed by pupation in the soil. The most harmful are the larvae of the first and second generations. Within a year, 3-4 generations of the pest can develop.

Prevention and control. It is necessary to carefully incorporate manure, which attracts flies and encourages the laying of eggs. An important care treatment is the destruction of flowering weeds that attract midges.

The finding of more than 10 % destroyed seedlings in the year preceding the crop indicates the need to perform a treatment to combat cabbage root flies with one of the currently registered protection measures.

FLIES (Diptera) — Cecidomyiidae family

Pea midge - *Contarinia pisi* (Loew). It occurs mainly in the north of the country. It feeds on various species of plants of the Fabaceae family, including pea and broad beans.

Type of damage. The larvae feed on different parts of plants. Damaged flower buds and flowers become excessively large, dry out, and fall off. The pods are deformed, smaller, and covered on the inside with a white coating (this is a layer of fibres produced at the site where the larvae suck the juices). As a result of the larvae feeding, seeds are distorted. With a large pest population, the plant does not set pods.

Pest description. Adult individuals are yellowish or brown in colour, 2-3 mm long, with transparent wings covered with dark hairs. They look like mosquitoes. The larvae are legless, initially white, later yellow, 2 mm long. Eggs are oval, transparent, 0.5 mm long, and difficult to see with the naked eye.

Biology outline. Larvae overwinter in cocoons, in the top layer of the soil. The pupation takes place in the spring. At the end of May and in June, the emergence of flies takes place. Females lay eggs in clusters of up to approximately 30, in flower buds, in pods, and between the top leaves of the shoot. After several to a dozen days, the larvae hatch. They feed for about 2 weeks. Then they fall to the ground, where some overwinter until the next year, and some give rise to the second generation. In July, the flies of the next generation appear. The larvae of the second generation feed exclusively on pods.

Prevention and control.

The infestation of pea by the pest limits early sowing and the cultivation of varieties that bloom early and quickly fade. It is recommended to maintain spatial isolation (minimum 400 m) from last year's crops. Deep winter ploughing destroys wintering larvae.

Finding from 25 to 30 egg deposits per 1 m^2 of cultivation indicates the need to combat pea midge.

BEETLES (Coleoptera) — Curculionidae family

Striped weevil - *Sitona lineatus* (Linnaeus)

Sitona macularius - *Sitona macularius* (Marsham)

It is common throughout the entire country. It damages plants of the Fabaceae family, including pea and broad beans.
Type of damage. Beetles appear in the field very early. They damage germinating seeds and then young plants. Symptoms of feeding are visible in the form of sinusoidal notches on the edges of the leaves. Larvae of the weevil feed on root nodules (*Rhizobium leguminosarum*), which results in a reduced ability to fix atmospheric nitrogen.)
Pest description. Depending on the species, adult beetles are 4 to 8 mm long, grey or brown, with lighter lines on the head and pronotum. The wing covers cover the entire abdomen and have alternately lighter and darker stripes. The head is elongated and ends with a thick, short snout. The larvae of the weevil are white or cream, with a dark head, legless, up to 6 mm in length, and arched. Eggs are oval, cream-white after being laid, and later darken, reaching a length of up to 0.3 mm.
Biology — an outline. Adult beetles overwinter in the soil and in plant debris. In April, they appear and begin feeding on perennial leguminous plants, and then fly to fields with pea and broad beans. Females, after fertilisation, lay eggs in the soil or on the leaves, usually at the turn of May and June. After about 14-21 days, larvae hatch, which feed on root nodules. After approximately 30-55 days, they pupate in the soil. Beetles will appear in July, feeding, among other things, on clover and alfalfa. In autumn they switch to wintering. One generation of the pest develops a year.
Prevention and control. It is recommended to sow plants away from legume plantations, from where the pest can fly onto pea. Proper agricultural techniques are very helpful in reducing the number of weevils. The use of mechanical tillage after harvesting promotes the ejection of beetles onto the surface of the soil, where they are eaten by birds. If possible, the sowing date should be accelerated. Thanks to this, the plants will be able to produce a few true leaves before the beetles appear. In addition, just after sowing, the rows of plants can be covered with crop cover, which will serve as a barrier to hinder the pest from settling on the seedlings.
If approximately 10 % of leaves with edge bites are found during the emergence period, a treatment should be carried out using one of the currently registered zoocides intended for the control of weevils.

BEETLES (Coleoptera) - Bruchidae family
Pea weevil- *Bruchus pisorum* (Linnaeus)
Type of damage. The larvae bore a short tunnel inside the seed. The damage is visible on the surface of the seed in the form of a small entrance hole. Beetles feed on leaves.
Pest description. Adults are grey to black, approximately 4-5 mm in length. The elytra are covered with white bristles forming spots and are shorter than the abdomen. There is a large white spot at the end of the abdomen. The egg is yellow in colour, cigar-shaped with dimensions of 1.5 mm x 0.6 mm. The whitish larva, legless, arched, with a brown head, grows to 6 mm in length.

Biology — an outline. Beetles overwinter in stored seeds. In the spring, they leave them and fly to pea plantations. Females lay eggs individually on developing pods immediately after the end of flowering. One female can lay up to 500 eggs. After hatching, the larvae bore into the seeds, where they go through their entire development cycle. In autumn, beetles leave the seeds and move to wintering sites or remain in the seeds until spring. There is one generation per year.

Prevention and control. Care must be taken to ensure the purity of the seed in order to eliminate the possibility of the pest being introduced into the field. In the storage rooms, it is necessary to inspect the seeds.

Observations for the presence of the pest should be carried out in the final phase of flowering and the beginning of pod formation. In the field, after the occurrence of the pest, treatments with registered plant protection products should be carried out no more than twice per season.

TRUE BUGS (Hemiptera) — the Aphididae family

Pea aphid - *AcAcyrthosiphon pisum* (Harris)

The pest is found throughout the country. It feeds on pea, lentils, alfalfa, sweet clover, and other plants of the Fabaceae family.

Type of damage. Symptoms of feeding are visible primarily on the tops of shoots in the form of deformation. Aphids can also feed on leaves, inflorescences and pods. With a large population of the pest, there is a weakening of growth, the death of infested organs, and even entire plants. Sites damaged by aphids are susceptible to infection by various pathogens. Pea aphid is a vector of viruses, including virus V (BYMV – *Bean Yellow Mosaic Virus*).

Pest description. Depending on the biotype, aphids can be light green or pink. The body length of wingless individuals ranges from 3.2 mm to 5 mm. The head of the aphid is yellowish-green. Siphons (tubes on the abdomen) are thin, long, green with a brown end, 1.2 to 1.9 times as long as the tail. The tail is long and sharply pointed. The antennae are longer than the body. Winged forms have two pairs of membranous wings.

Biology outline. They overwinter eggs on perennial leguminous plants. In the spring, larvae hatch from the eggs and feed on young leaves. Winged forms appear at the turn of May and June and fly onto pea. They form numerous colonies there. At the end of the growing season, winged forms appear again, which migrate to perennial legumes and lay overwintering eggs there. During the season, up to 9 generations of the pest develop.

Prevention and control.

Spatial isolation from other leguminous plants helps reduce the occurrence of pea aphids. Weeds should not be allowed to infest the crop, as aphids can develop and overwinter on them. In areas where the pest is often present, it is recommended to sow varieties that grow quickly and bloom early. Due to the risk of virus transmission, the apical parts of the shoots should be inspected at least once a week.

Detection of 5 or more aphids per plant up to 15 cm high on the apical parts of the shoots indicates that the threshold of danger has been exceeded and necessitates the performance of a treatment.

LEPIDOPTERA (Lepidoptera) - Tortricidae family

Pea moth - *Cydia nigricana* (Fabricius)

It is found throughout the country. It causes the greatest damage on the pea plantation, to a lesser extent on the broad bean.

Type of damage. On plantations with a delayed sowing date, the hatched caterpillar, not finding developed pods, feeds in growth cones and even in young shoots. The caterpillars penetrate into the pods, where they feed on the developing seeds until they reach full maturity, contaminating the inside of the pod with faeces and silk. Damaged seeds lose their commercial value and are not suitable for sowing.

Pest description. Moth with a wingspan of approximately 14 mm. The front wings are olive brown, with yellow and grey scales. On the upper edge, black and white lines are arranged alternately. The rear wings are grey-brown. The eggs are oval, milky white in colour. The caterpillar is approximately 10 mm long, yellow-green, with dark brown warts, on which there are bristles. The dark brown pupa is approximately 8 mm long.

Biology outline. Caterpillars overwinter surrounded by a cocoon in the soil at a depth of approximately 5 centimeters. In the spring, pupation occurs. At the end of May and the beginning of June, moths emerge. After mating, the female lays eggs on leaves, stems and pods. One female can lay up to approximately 180 eggs. After hatching, the caterpillars bore into the pods and begin intensive feeding on the seeds. When the pods are missing, the caterpillar feeds at the tops of the shoots, on the leaves. After approximately 3 weeks, the adult caterpillar descends on a thread into the soil and overwinters there in a cocoon. There is only one generation per season.

Prevention and control

Early sowing of pea, early removal from the field and threshing are recommended, as well as, if possible, collecting and destroying damaged pods. Deep ploughing of the field after harvest largely limits the emergence of caterpillars in the spring. All these treatments are aimed at preventing the completion of the development of caterpillars.

The presence of the pest is favoured by dry and warm weather.

Chemical control is carried out at the beginning of caterpillar hatching. Pheromone traps are helpful for monitoring the flight of males. After 7-10 days from observing the first pea moths, protective treatments should be performed. If necessary, repeat spraying after 7-10 days.

Locally, in the cultivation of field pea, damage can be caused by soil pests (mainly beetle larvae—grubs and wireworms—and cutworm caterpillars), and on the above-ground parts—caterpillars of moths, Lygus pratensis, red spider mites, pea thrips, pea midge, snails, and others.

Information on identifying, monitoring, and protecting pea (sugar and husk pea) from pests is also available at:
https://www.inhort.pl/files/sor/poradniki_sygnalizatora/Poradnik_sygnalizatora_groch_siewny.pdf

6.1. Methods of plant protection against pests

Agrotechnical method

Location of plantations. Pea plantations should be located with spatial isolation from fields where plants of the Fabaceae family grew in the previous year.

Crop rotation. Crop rotation is an important element of crop rotation, one of the principles of which is to maintain soil health by avoiding the cultivation of directly related crops or crops attacked by the same pests.

Soil mechanical cultivation.

Deep ploughing destroys many pests that live in the soil or significantly limits their proper development.

Regulating the times of sowing and harvesting.

The selection of an appropriate date for planting reduces losses caused by pests in the early development phase of crops. Similarly, harvesting in a timely manner can significantly reduce the damage caused by pests.

Weed control.

The weed infestation of the fields facilitates the emergence of many pests. Weeds are host plants for many pest species (e.g. infested plantations are more strongly attacked by bean seed maggots, aphids, thrips, Lygus pratensis, and others).

Cultivation method

Pea varieties used in integrated production should be tolerant to adverse weather conditions. Tolerance of low temperatures and periodic water shortages is important, especially during the initial growth phase.

Mechanical method

It can be used in the protection of crops grown in small areas. The most common activities include collecting or removing pests from cultivated plants or their immediate surroundings.

Agrotechnical method

It uses pheromones (i.e. chemical insect messengers). In pea cultivation, synthetically obtained pheromone compounds are mainly used to lure male pea moths. The pheromone dispenser is placed in a triangular trap with an adhesive floor. The number of moths caught should be checked twice a week. Due to the volatilisation of the fragrance, it is recommended to replace the dispenser on average every 4-5 weeks.

Biological method

In the fight against pests, their natural enemies (parasites and predators) occurring in the field during the growing season play an important role. When conditions are favourable for their development, they prevent the mass (gradational) occurrence of herbivorous species on crops. Both micro-organisms (including fungi of the genus *Beauveria*, *Paecilomyces*, various strains of bacteria *Bacillus thuringiensis*) as well as macro-organisms (including parasitic nematodes of the genus *Heterorhabditis*, *Steinernema*, predatory insects, e.g. Coccinellidae, Syrphidae, and many others) help control the pest population.

6.2. Chemical protection against pests

Plant protection products should be used in accordance with the recommendations given on the label and in a way that does not endanger human health, animals, or the environment. These products should have high selectivity for zoophages (predators and parasites), low toxicity to humans and animals, fast decomposition dynamics and non-accumulation in the environment, and a safe formulation. Agents with the shortest possible withdrawal period should be applied, especially in the case of interventions carried out during the period when the vegetables reach consumption maturity. Non-chemical agents should be included in the plant pest management programme (at least one of the treatments performed should be carried out with such a preparation). In order to prevent the development of pest resistance to the zoocides used, it is recommended, as far as possible, to use products belonging to different chemical groups.

When deciding whether to perform a chemical treatment, three thresholds related to pest abundance are helpful. The first of these is **harmfulness threshold** determining the population size at which the least loss in yield quantity or quality can be observed. The next threshold is called **threshold of economic harmfulness** and determines the size of the pest population at which the cost of performing a protective treatment is equal to the loss of the value of the crop caused by this pest.

However, if the treatment is carried out when the pest population corresponds to this threshold, there is a risk that the pest population will continue to increase for various reasons, and then yield losses may exceed the cost of the treatment. In order to prevent such a situation, the treatment should be performed before the pest population reaches the threshold of economic harmfulness. This number of pests is called **the threat threshold.**

It should be stressed that the proposed threat thresholds are only indicative and cannot be applied indiscriminately in every situation, as they depend on many variables.

When deciding whether or not to carry out a control treatment, the producer must take into account the phenological phase of the plant, the tolerance of the cultivated variety to the pest, the co-occurrence of diseases and other pests, the degree of resistance of the pest to available chemical preparations, the costs of protective treatments, as well as the expected yield and profit from the sale of pea.

The list of plant protection products approved for sale and use in Poland is published in the register of authorised plant protection products. Information on the scope of application of pesticides in individual crops is included on the labels. The plant protection product search engine is a helpful tool when selecting pesticides. Up to date information on the use of plant protection products may be found on the website of the Ministry of Agriculture and Rural Development at https://www.gov.pl/web/rolnictwo/ochrona-roslin. The list of plant protection products authorised for integrated production is drawn up by the Institute of Horticulture – National Research Institute in Skierniewice and published in the Vegetable Plant Protection Programme and on the website of the Institute of Horticulture – National Research Institute (https://www.inhort.pl/files/sor/wykaz_srodkow_ip/Wykaz_fungicydow_do_IP_w_uprawach_warzyw_gruntowych.pdf) and the Pest Alerting Platform (https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji).

6.3. Pest monitoring in pea cultivation

Monitoring of harmful organisms can be carried out using various methods and tools. One of the commonly used methods is the visual method, which involves inspecting the plants on the plantation for pests or damage caused by them. For the correct identification of insects, magnifiers with a minimum magnification of 4 times (the larger the magnification, the better), used directly on the plantation, are very useful.

For monitoring the flight of moths (e.g. pea moth), it is recommended to hang traps with pheromones. Coloured sticky boards are also useful: yellow for observing aphid infestations, blue for observing thrips infestations, white for observing leaf miner flies. The presence of soil pests is best checked by randomly taking 32 soil samples from pits with dimensions of 25 x 25 cm and a depth of 30 cm (total sample area 2 m^2), then sifting through a sieve and counting the larvae present.

The results of observations are recommended to be recorded, as they are helpful not only when deciding on the necessity of performing a control treatment, but also when forecasting the threat from herbivores in the following years.

6.4. Protection of beneficial arthropods

A very important role in limiting the number of pests is played by beneficial fauna, i.e. numerous predatory and parasitic species that naturally occur on pea plantations and in

their surroundings. Thanks to its presence, it is often possible to reduce the number of pesticide treatments performed.

To maintain or increase the number of natural enemies of pests on the plantation, you should first of all:

- use plant protection products that are selective or partially selective for beneficial fauna, including biological preparations based on micro-organisms (viruses, bacteria, fungi),
- use mechanical preparations to control certain pests (e.g. aphids, spider mites),
- increase crop biodiversity by leaving or creating so-called ecological areas, which include field trees, field margins, ponds, flower strips, etc. They serve as habitats and wintering sites for many beneficial arthropods.
- install resting poles for birds of prey at a rate of at least 1 per 5 hectares, or, in the case of larger plantations, several poles.

On pea plantations, an important group of natural pest enemies are beetles from the families Carabidae, Cicindelidae, Staphylinidae, and Coccinellidae. The main sources of food for them are aphids, caterpillars, moth pupae, and larvae of other beetles and flies (including root maggots). An important role in limiting the number of aphids is played by predatory larvae of flies from the Syrphidae and Cecidomyiidae families, as well as lacewing larvae, the most well-known representative of which is the common green lacewing. Useful arthropods also include earwigs (which eat, among others, aphids and the eggs of the pea moth), and predatory bugs from the Anthocoridae family (which attack, among others, aphids, thrips, and spider mites). Spiders also play a role in reducing the number of many dangerous pests. Among the pest parasites, the parasitic hymenoptera of the families Ichneumonidae, Braconidae, and Aphidiidae should be mentioned primarily. The beneficial fauna also include representatives of amphibians, reptiles, mammals, and birds (e.g. frogs, lizards, snakes, hedgehogs, insectivorous birds, and birds that hunt rodents).

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6.5. Protection of pollinators

In addition to the natural enemies of pests, an important group of insects are pollinators, mainly from the bee family. Their presence has a positive effect on the size and quality of the crop. In order to increase their number in cultivation, it is necessary to set up shelters for mason bees and nesting boxes for bumblebees. In the case of a house for mason bees, the structure should have at least 200 nest ducts with an appropriate diameter of 5-8 mm and a length of 14-20 cm. At least 70 % of nesting material (nest ducts) should consist of cut reed tubes. The other material used for the shelters may include other cut plant stems with a hollow section, or drilled blocks of wood with the above-mentioned parameters.

In the case of bumblebees, it is recommended to issue covered wooden hatching booths measuring about 20x15x10 cm with an entrance hole of 2 cm in diameter. Inside the booth material for the construction of an external nest, e.g. chafed dry grass,should be provided. Booths can be placed on the ground, above the ground or creating “mounds” i.e.

burying booths halfway into the ground. The entrance to the nest should be easily accessible, not overgrown or obscured. The preferred place to set up booths is the edge of the plantation.

VII. PROVISIONS AND PRINCIPLES OF GOOD PRACTICE OF HANDLING PLANT PROTECTION PRODUCTS

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Plant protection with chemicals poses specific risks to the operator and the environment. In order to minimise the resulting risks, the operator of the treatments must have appropriate authorisations to use plant protection products and use them skilfully, with particular care, always in accordance with the law and the provisions of the label-instructions for use, and with the use of technically efficient and calibrated equipment for the treatments. Authorisations regarding personnel and equipment, as well as the procedures for handling plant protection products, in particular with respect to the activities performed before and after the treatment, are specified in the provisions of the Ministry of Agriculture and Rural Development regulations. They are complemented by the principles of Good Plant Protection Practice.

7.1. Authorisations and conditions of use of plant protection products

According to the regulations, plant protection products may be purchased and used only by persons trained in the use of these products and holding a certificate confirming the completion of the relevant training. The certificate of completion of these training courses is valid for a period of 5 years, and their renewal can be obtained each time after completing the supplementary training.

Equipment for the application of plant protection products must be technically sound so as not to pose risks to human health, animal health, and the environment. Sprayers must be tested at intervals of no more than 3 years. The first inspection of new equipment is conducted no later than 5 years from the date of its purchase. Until then, the document permitting the use of the sprayer for plant protection products is the purchase invoice. The efficiency of the equipment is confirmed during diagnostic tests carried out in authorised sprayer inspection stations. A positive result of the inspection shall be confirmed by a technical inspection report and a control mark in the form of a sticker affixed to the sprayer tank.

To ensure the correct application of crop protection products, the sprayer must be calibrated. This is a legal obligation for sprayer users, who can and should carry out the calibration themselves. Although the regulations do not specify how often it should be repeated, in accordance with good practice, it is recommended to calibrate the sprayer at

least at the beginning and in the middle of the plant protection season. It is also worth documenting the calibration in the form of a record of assumptions and results of subsequent operations. The calibration process is described in one of the following subsections.

Treatments with plant protection products should be recorded. Records of treatments should include the following details: the dates of application, the species of crops treated and their areas, the areas treated, the names of the plant protection products used and their doses, and the reasons for their use. Records should be kept for at least 3 years from the date of the plant protection treatment.

The spraying process, even with the use of an efficient and calibrated sprayer, suffers from the drift of the spray liquid, which creates a risk of contamination of sensitive areas, such as surface water, apiaries, or other non-agricultural areas. In order to prevent this risk, it is necessary to maintain the buffer zones indicated on the labels between the place of application of plant protection products and sensitive facilities. Labels may also indicate the possibility of reducing the buffer zone if drift reducing equipment is used to a certain extent. The classification of drift reducing techniques (DRT) is available on the Institute of Horticulture - National Research Institute website https://www.inhort.pl/serwis-ochrony-roslin/, under Plant Protection Technique. Where a buffer zone is not indicated on the label of the plant protection product, the following general rules on minimum buffer zones shall apply: for public roads, excluding municipal and district roads - 3 m; for apiaries - 20 m; for reservoirs, watercourses and non-agricultural areas - 1 m for field sprayers and 3 m for orchard sprayers.

The most significant objective factor affecting the removal of plant protection products is wind. Excessive wind increases the risk of environmental pollution, even despite the use of drift-reducing techniques. Therefore, the maximum wind speed at which plant protection products can be used is legally defined. It is 4 m/s, regardless of the spraying technique used.

The greatest threat to the environment, and especially to water, is local pollution caused by leakages or dispersal of concentrated plant protection products during their storage and preparation of the spray liquid, as well as the lack of safe disposal options for residues from treatments, i.e. remnants of the spray liquid, water from rinsing the liquid system, and external washing of sprayers. They may also arise as a result of non-compliance with the rules for handling empty product packaging. The provisions concerning the storage of plant protection products, the preparation of the liquid, the washing of the sprayer and the management of liquid residues are laid down in the Regulation of the Minister for Agriculture and Rural Development on the management and storage of plant protection products and plant protection products (Journal of Laws of 2013, item 625). The Regulation imposes a general requirement to proceed in a way that reduces the risk of contamination of surface water, groundwater and land, which directly translates into the reduction of local pollution.

7.2. Storage of plant protection products

Specific storage requirements for plant protection products shall ensure that they are kept in their original packaging in such a way as to prevent contact with food, drink or feed and accidental human or animal consumption. The storage place or facility must be capable of being closed to prevent access by third parties, in particular children. If this place is not located on a hardened surface impermeable to liquids (e.g. a floor made of airtight concrete or other durable materials), it must not be closer than 20 m to wells, reservoirs, and watercourses. In addition, it must ensure that plant protection products do not enter open sewage systems. This means that any drains from the grids leading to the sewage system must be closed, unless it is a drainless (closed) system equipped with a sealed tank or device that neutralises the active substances of plant protection products.

The regulation does not require the storage of resources in a specially designated room, which means that small quantities can be stored in cabinets. It is important that the cabinet be made of durable materials and lockable with a key or padlock, and that it prevents substances from escaping outside. For this purpose, a tray at the bottom of the cabinet can be placed to collect accidental leaks.

The labelling of plant protection products imposes additional requirements to guarantee their durability and effectiveness. For this purpose, the products should be stored at a temperature not lower than 0°C and not higher than 30°C, in dry, cool, and properly ventilated places. They should be protected from moisture and direct exposure to heat sources.

Good practice adds to this non-mandatory but practical recommendations, which aim to enhance and further raise the level of safety at work with plant protection products and to enable effective action in emergency situations. In accordance with the principles of good practice, the place of storage of products should be appropriately marked and illuminated. Excess stocks of products should not be accumulated, but only the amount intended for use within 6-12 months should be stored. The shelves on which the products are placed should be made of a non-absorbent, easy-to-clean material. Wooden shelves can be covered with foil. The agents should be grouped according to their purpose and degree of harmfulness, placing loose preparations (powders and granules) over liquid ones. A separate shelf should be allocated for substandard products intended for disposal. In the room, there should also be an accessible, well-lit place for the scale, a measuring jug, and a spatula, intended for measuring preparations to make a spray liquid. It should be borne in mind that all tools in contact with plant protection products must not be used for other purposes. There should also be space for emptied and rinsed product packaging and for a brush, scoop, sawdust container (or other material absorbing spilled liquids), a roll of paper towel, and a container for contaminated waste (e.g, sawdust after collecting spills or a towel after wiping tools). In large rooms, it is also advisable to ensure the presence of a fire extinguisher, emergency phone numbers, and health and safety instructions, which should be displayed in a visible location at the entrance to the facility.

7.3. Preparation of the spray liquid

When preparing the spray liquid, the sprayer operator is exposed to the active substance in the highest concentration, therefore, he must use appropriate protective clothing (e.g. cat. III, type 4, 5 or 6), rubber footwear and nitrile gloves, and appropriate eye protection (goggles) or full face protection (protective screen) suitable for the degree of toxicity and formulation of the preparation, as well as respiratory protection (half-mask: filtering P2 or P3, absorbing A2, or filtering-absorbing P2A2). When measuring preparations, extreme care should be taken to avoid spillage, splashing, or dispersal, which would result in the risk of serious local contamination. Due to the high level of risk associated with the preparation of a spray liquid, the provisions of the Ministry of Agriculture and Rural Development Regulation require this activity to be carried out at a distance of at least 20 m from wells, water intakes, reservoirs, and watercourses. The instructions on the product label require precise determination and measurement of the amount of preparation needed to prepare the liquid. For this purpose, it will be necessary to perform a simple calculation according to the following relationship:

$$\text{Quantity of product [l, kg]} = \frac{\text{Product dose [l, kg/ha] x Liquid volume in the tank [l]}}{\text{Liquid dose [l/ha]}}$$

The liquid should be prepared immediately before use and used without delay. When considering the mixing of different agents, attention should be paid to the possibility and justification of their combined use, and when preparing the mixture, preparations should be added to the water in the order recommended by the manufacturer. The preparation of the spray liquid should always be carried out with the agitator switched on in order to prevent the suspension from depositing in the nooks and crannies of the container. If the mixing of liquids results in the formation of abundant foam in the tank, the intensity of mixing should be minimised, for example by reducing the engine speed in the tractor.

The preparation of the spray liquid in the field, each time in a different place, prevents the accumulation of concentrated substances at one point as a result of accidental, even minor, but difficult to avoid leaks. These minor spills or scattering of substances onto the biologically active substrate of the field undergo natural biodegradation, minimising the risk of local contamination. For the safe preparation of liquids in the field, a preparation diluter is used, which is an additional device of the sprayer. Using a diluent, we prepare a concentrate of the plant protection product based on a small amount of water from the tank. This concentrate is then drawn into the main tank by means of ejection and mixed with water. Empty packaging is rinsed using a pressure washer equipped with a dilutor. In order to improve and maximize the safety of the entire process, it is advisable that the sprayer be also equipped with a storage compartment for plant protection products, empty packaging, a measuring cup for liquid preparations, and a clean water tank for washing hands. N.B: the

use of a diluent does not eliminate the need for the operator to use personal protective equipment.

If the absence of a diluent on the sprayer prevents the preparation of liquids in the field, or for other reasons this activity must be carried out on the farm, then care should be taken to choose the right place. In addition to the prescribed 20 m from wells, water intakes, reservoirs, and watercourses, good practice recommends that the sprayer be filled on a bounded station with an impermeable substrate, i.e, one that prevents water from seeping into the ground and spreading outwards, as only in this way is there a guarantee of avoiding contamination of the soil and surface and groundwater. The ideal solution is a station in the form of a concrete slab with the flow of contaminated water into the collection well, from where it is further directed to safe management. In the absence of such solutions on the farm, the soil can be protected against contamination by spreading a film or laminated sheet under the sprayer, from which any spills can be rinsed into the sprayer tank.

When replenishing the water in the sprayer tank, the liquid level indicator should be carefully observed to ensure that under no circumstances does the tank overflow and mass leakage occur, but only the volume of water needed to spray the specified area of the field is taken.

7.4. Washing the sprayer

Sprayer washing usually involves contamination of the ground with a large amount of polluted water, which can flow into reservoirs or watercourses or seep deep into the soil profile into groundwater. This risk can be significantly reduced by safely managing the water after rinsing the liquid system and collecting and neutralising contaminated water after external washing. The provisions of the Regulation of the Ministry of Agriculture and Rural Development and the instructions on the label of the products clearly require that the liquid residues after the treatment be diluted with water and sprayed on the previously treated surface. The same procedure should be applied to subsequent portions of water used for rinsing the tank and liquid system three times. In fact, it is a practical and relatively safe way to handle the remaining liquid and contaminated water. A legal alternative is the neutralisation of liquid residues by biodegradation of active substances in bioremediation sites. Under no circumstances may these residues be discharged onto the ground, into sewage systems or in any other place not intended for the neutralisation of plant protection products or the disposal of chemical waste.

For efficient internal cleaning of the liquid system in the field, an additional water tank and a pressurised sprinkler are required to flush the tank. Internal washing of the sprayer is usually carried out in three cycles by successive dilutions of the residues of plant protection products. Half of the additional reservoir water is used for the first dilution, and 25 % for each of the next two. After each dilution, the contaminated water should be sprayed in accordance with the above-mentioned provision of the Regulation. The sequential dilution method shall ensure that, at the end of the operation, the concentration of the active substance in the water remaining in the sprayer system is not more than 2 % of the initial

concentration of the spray liquid. The whole process can be automated using a programmable computer. Particularly noteworthy is the continuous internal washing system, which uses an additional pump to operate the tank rinsing sprinklers. During rinsing, the diluted residues are continuously sprayed onto the field, which doubles the speed of the washing process and halves the volume of water used. Due to the substances flushed from the sprayer during external washing, the provisions of the Ministry of Agriculture and Rural Development Regulation specify a minimum distance of 30 m between the washing site and wells, water intakes, reservoirs, and watercourses. This requirement does not apply to washing facilities for plant protection equipment that meet specific technical requirements (a hardened surface made of impermeable concrete, a sealed mud and grease trap, and a sealed sewage tank).

Good practice recommends washing the sprayer in the field using an external washing kit, supplied with water from an additional tank. In the field, the rinsed substances end up on a biologically active substrate and undergo biodegradation. Each time, the sprayer should be washed in a different location to avoid the accumulation of substances in the soil. If circumstances prevent washing in the field, this operation should be carried out on a bounded impermeable surface with a slope to the separator for solid parts and petroleum products, from where contaminated water can be directed for safe management. The recommended ways of managing liquid residues are bioremediation, i.e. biological degradation of substances under the influence of soil micro-organisms, or dehydration, i.e. evaporation of water under the influence of solar radiation and wind, and subsequent disposal of the remaining sludge by entities authorised to eliminate hazardous waste.

7.5. Packaging

Packages of plant protection products classified as hazardous substances (marked with the pictogram GHS 06: Health hazard – Acute toxicity 1, 2, 3, or GHS 09: Hazard to the environment – Toxicity to the aquatic environment) are hazardous wastes that are subject to special treatment as defined in the Packaging and Packaging Waste Management Act (Journal of Laws of 2013, item 888). The provisions of the Act impose on the user of these agents the obligation to return the packaging to the seller, and on the sellers the obligation to accept this packaging and direct it for safe disposal. The label instructions shall indicate if the packaging is to be treated as hazardous waste, in which case it shall mandate rinsing the emptied packaging three times with water and pouring the rinses into the sprayer tank with the spray liquid. Instead, a packaging scrubber may be used, but then the pressure rinsing must not take less than 10 seconds. Rinsed packages should be collected in specially marked plastic bags and returned to the seller in this form. The label prohibits the burning of packaging on one’s own and its use for other purposes, including as secondary raw materials. Labels of plant protection products not classified as hazardous substances shall include information on treating packaging as municipal waste. In this case, the incineration of packaging is still prohibited. After rinsing, they can be placed in a plastic or paper container.

VIII. SELECTION OF TECHNIQUES FOR THE APPLICATION OF PLANT PROTECTION PRODUCTS

The manner and conditions of the use of plant protection products largely determine the effectiveness of treatments, safety of the operator and the environment. In accordance with the requirements of integrated plant protection, plant protection products should be used sparingly, precisely, and with the least possible losses, especially those resulting from the drift of the spray liquid. Therefore, treatments with plant protection products should be carried out under appropriate weather conditions, preferably under optimal and favourable conditions, but never exceeding the limit of acceptable conditions. The characteristics of different categories of weather conditions are shown in Table 2.

In the protection of vegetables, field sprayers with a conventional boom or with an auxiliary air stream (AAS) are primarily used. The air flow compensates for the wind and causes deep penetration of crops, significantly reducing the losses of the spray liquid. PSP sprayers, in almost all permissible weather conditions, enable the even distribution of liquids on plants using fine droplets and liquid doses reduced by half. In addition, the AAS technique enables effective and safe treatments at high operating speeds of 10-12 km/h, which, in combination with low liquid doses, allows for high work efficiency.

Table 2. Characteristics of weather conditions during plant protection treatments

Conditions	OPTIMAL	FAVOURABLE	ACCEPTABLE
Air temperature [°C]	10-15	up to 20	up to 25*
Air humidity [%]	60-95	>50	>40 *
Wind speed [m/s]	0.5-1.5	up to 2.0	**up to 4.0****
Recommended droplet size	SMALL AVERAGE	AVERAGE THICK	THICK VERY THICK

**according to good practice*

***according to the law (Ordinance of MoARD of 31.03.2014 – Journal of Laws 2014, item 516)*

8.1. Types and variants of sprayers

On the field booms of conventional and AAS sprayers, pressure flat-jet sprayers with a spray angle of 110° or 120° are mounted. With a standard sprayer spacing of 50 cm, even distribution of liquid on plants is achieved with the boom maintained at a height of 40-50 cm above the crop. In order to keep liquid losses as low as possible, the boom should not be raised above this height.

The type of sprayers used and the parameters of operation – mainly pressure – determine the size of droplets produced, the dose of liquid and the way it is applied on plants, which are the basic factors determining the effectiveness of treatments and the loss of plant protection products. These factors primarily affect plant coverage and liquid

retention, i.e. the amount of liquid retained on the sprayed surface, and ultimately the level of application and uniformity of distribution of the active substance of the plant protection product in the vegetables. In addition, sprayers are the main cause of loss of plant protection products due to drift and run-off of liquids from plants. When choosing sprayers, it is necessary to take into account the applied dose of liquid, the operating speed of the sprayer, and weather conditions, especially wind speed (tab. 3). These circumstances determine the required discharge of the sprayer and the size of the droplets produced, allowing for the selection of the appropriate type and size of the sprayer.

Two types of flat-jet sprayers are distinguished, depending on the method and effect of spraying: standard and ejector. Standard sprayers produce fine and very fine droplets, especially prone to drift. Their use should be limited to carrying out treatments in optimal and favourable weather conditions when the wind speed does not exceed 2 m/s; They are particularly recommended for the use of fungicides and zoocides in the early developmental stages of plants, for controlling diseases and pests on the apical parts of plants, and for treatments in conditions of light dew, enabling the use of low doses of liquids. The AAS technique can be used in all permissible weather conditions.

Ejector sprayers produce coarse and very coarse droplets with air bubbles, formed as a result of air suction and mixing with a liquid during the spraying process. The aerated liquid in the sprayer prevents the formation of small droplets, the most susceptible to drift. Ejector sprayers are particularly suitable for applications in conditions with a high risk of drift when the wind speed exceeds 2.5 m/s or when the operating speed is above 8 km/h. Depending on the type, they produce one or two spray jets. Single-jet sprayers are available in the long version, for which the operating pressure range is from 3.0 to 8.0 bar, and in the compact version, operating in the same pressure range as standard sprayers, i.e. 1.5-5.0 bar. In both versions, the use of fungicides and zoocides is recommended in late growth phases, when deep penetration of tall and dense crops is needed, as well as for the application of soil herbicides in any, even suboptimal weather conditions. Dual-stream sprayers produce two streams of drops, one of which is tilted forward and the other backward, usually +30°/-30°. This solution is used to align the application on the inrun (front) and outrun (back) vertical surfaces of objects, such as onion chives, leek leaves, or root vegetable tops, as well as pea fields. Using them, any treatment can be carried out on all vegetable species and at all stages of growth. They are particularly effective after plant thickening, when good penetration of the crop is necessary.

8.2. Sprayer size.

The size of the sprayer, indicated by the appropriate ISO symbol and colour, and the pressure of the liquid determine the sprayer output expressed in litres per minute [L/min]. Flat-jet sprayers are used in the pressure range from 1.5 to 5.0 bar (long ejector: from 3.0 to 8.0 bar). The dependency of discharge on sprayer size and pressure is shown in Table 3, which is part of the catalogues of sprayers produced in accordance with the ISO standard. It allows for quick identification of the pressure and operating speed of the sprayer to obtain

the required dose of liquid, expressed in litres per hectare [L/ha]. For example, a dose of 200 L/ha can be achieved using both sprayers 02 and 03, but at different pressures and driving speeds. For sprayers 02, the most similar doses of liquid are obtained at a pressure of 2 bar and a speed of 4 km/h or 5 bar and 6 km/h, while for sprayer 03 it is 1.5 bar and 5 km/h, 3 bar and 7 km/h, or even 6 bar and 10 km/h.

Table 3. Liquid discharge [L/min] for ISO sprayer sizes 01 to 06 versus liquid pressure [bar] and liquid dose [L/ha] at different operating speeds [km/h]

01		L/ha						
		km/h						
bar	L/min	4,0	5,0	6,0	7,0	8,0	10,0	12,0
1,5	0,28	85	67	57	48	42	34	28
2,0	0,33	98	79	65	56	49	39	33
2,5	0,37	110	89	73	63	55	44	37
3,0	0,40	120	96	80	69	60	48	40
4,0	0,46	139	110	92	79	69	55	46
5,0	0,52	155	125	103	89	77	62	52
6,0	0,57	171	137	114	98	86	68	57
7,0	0,61	183	146	122	105	92	73	61
8,0	0,65	195	156	130	111	98	78	65

03		L/ha						
		km/h						
bar	L/min	4,0	5,0	6,0	7,0	8,0	10,0	12,0
1,5	0,85	255	204	170	145	127	102	85
2,0	0,98	294	235	196	168	147	118	98
2,5	1,10	329	264	219	188	164	131	110
3,0	1,20	360	288	240	206	180	144	120
4,0	1,39	416	334	277	238	208	166	139
5,0	1,55	465	372	310	266	232	186	155
6,0	1,64	492	395	328	281	246	197	164
7,0	1,79	537	430	358	307	269	215	179
8,0	1,91	573	460	383	328	288	230	191

015		L/ha						
		km/h						
bar	L/min	4,0	5,0	6,0	7,0	8,0	10,0	12,0
1,5	0,42	127	101	85	73	64	51	42
2,0	0,49	147	118	98	84	73	59	49
2,5	0,55	164	132	110	94	82	66	55
3,0	0,60	180	144	120	103	90	72	60
4,0	0,69	208	166	139	119	104	83	69
5,0	0,77	232	185	155	133	116	93	77
6,0	0,84	252	199	168	144	126	101	84
7,0	0,90	270	216	180	154	135	108	90
8,0	0,96	288	231	192	165	144	115	96

04		L/ha						
		km/h						
bar	L/min	4,0	5,0	6,0	7,0	8,0	10,0	12,0
1,5	1,13	339	271	226	194	170	136	113
2,0	1,31	392	314	261	224	196	157	131
2,5	1,46	438	350	292	250	219	175	146
3,0	1,60	480	384	320	274	240	192	160
4,0	1,85	554	444	370	317	277	222	185
5,0	2,07	620	497	413	354	310	248	207
6,0	2,21	663	530	442	379	332	265	221
7,0	2,37	711	569	474	406	356	284	237
8,0	2,53	759	608	507	434	381	304	253

02		L/ha						
		km/h						
bar	L/min	4,0	5,0	6,0	7,0	8,0	10,0	12,0
1,5	0,57	170	137	113	97	85	68	57
2,0	0,65	196	156	131	112	98	78	65
2,5	0,73	219	175	146	125	110	88	73
3,0	0,80	240	192	160	137	120	96	80
4,0	0,92	277	221	185	158	139	111	92
5,0	1,03	310	247	207	177	155	124	103
6,0	1,11	333	266	222	190	167	133	111
7,0	1,19	357	286	238	204	179	143	119
8,0	1,27	381	306	254	218	191	152	127

05		L/ha						
		km/h						
bar	L/min	4,0	5,0	6,0	7,0	8,0	10,0	12,0
1,5	1,41	424	338	283	242	212	170	141
2,0	1,63	490	391	327	280	245	196	163
2,5	1,83	548	439	365	313	274	219	183
3,0	2,00	600	480	400	343	300	240	200
4,0	2,31	693	554	462	396	346	277	231
5,0	2,58	775	619	516	443	387	310	258
6,0	2,75	825	660	550	471	413	330	275
7,0	2,96	888	710	592	507	444	355	296
8,0	3,17	951	761	634	543	476	380	317

025		L/ha						
		km/h						
bar	L/min	4,0	5,0	6,0	7,0	8,0	10,0	12,0
1,5	0,70	210	168	140	120	105	84	70
2,0	0,81	244	194	162	139	122	97	81
2,5	0,91	274	218	182	156	137	109	91
3,0	0,99	298	238	198	170	149	119	99
4,0	1,15	346	276	230	197	173	138	115
5,0	1,28	384	307	256	219	192	154	128
6,0	1,40	420	336	280	240	210	168	140
7,0	1,52	456	365	304	261	228	182	152
8,0	1,62	486	389	324	278	243	194	162

06		L/ha						
		km/h						
bar	L/min	4,0	5,0	6,0	7,0	8,0	10,0	12,0
1,5	1,70	509	408	339	291	255	204	170
2,0	1,96	588	470	392	336	294	235	196
2,5	2,19	657	526	438	376	329	263	219
3,0	2,40	720	576	480	411	360	288	240
4,0	2,77	831	665	554	475	416	333	277
5,0	3,10	930	744	620	531	465	372	310
6,0	3,28	984	787	656	562	492	394	328
7,0	3,54	1062	850	708	607	531	425	354
8,0	3,79	1137	910	758	650	569	455	379

8.3. Sprayer calibration

Calibration consists of adjusting the operating parameters of the sprayer, i.e. the appropriate selection of sprayers, liquid pressure, operating speed and height of the field beam, so that plant protection products are applied precisely and with the smallest possible loss, precisely in the planned dose of liquid. The dose of the spray liquid [L/ha] should be selected depending on the plant protection product used, the development phase of the plants, and the spraying technique. The recommendations of the label or instructions for use of the product can be a guide. The general rules for selecting doses of the spray liquid for pea are set out in Table 4. The procedure for calibrating the field sprayer and the method of documenting the results are presented in Table 5.

Table 4. spray liquid doses [L/ha] for field pea

Development phase/type of treatment	Conventional technology	Air-assisted technology
Fungicides and zoocides		
Up to 25 cm or for joining rows	**200 - 400**	**100 - 150**
More than 25 cm or after row joining	**400 - 600 (800)***	**150 - 200 (400)***
Herbicides		
Soil-applied	**200 - 300**	**100 - 150**
Foliar-applied	**150 - 250**	**75 - 150**
* *combating troublesome diseases that require abundant plant spraying*		

IX. RECORD OF PLANT PROTECTION TREATMENTS

Landowners and users are required to keep records of their treatments with plant protection products, which should include the following information: the date of the treatment, the cultivated plant and its developmental phase, the area on which the treatment was performed, the name of the product used (trade name and name of the active substance), the dose of the product and the reason for the treatment (target harmful organism). This information should be supplemented with data on weather conditions (air temperature and humidity, wind speed) and treatment parameters, such as the dose of liquid and sprayers used, and the effectiveness obtained. Records of treatments with plant protection products must be kept for at least three years and must be made available to inspection bodies. They review, among others, plantations, machinery, equipment, premises, and protection measures used in integrated protection, as well as check the correctness of the documentation and records kept by the producer regarding the protection of a given vegetable species against pests and pathogens and weed control.

The documentation kept on the farm is a source of information that can serve the grower in subsequent years and facilitate crop protection. Extended information on the active substances of the agents used, their mode and mechanism of action, and their efficacy may also be useful. Apart from recording the procedures using plant protection substances, the grower should gather data on the presence of pests, their intensity and the date of their appearance in individual years, and the progression of weather conditions. The collection

and recording of such information require knowledge of the pests and the symptoms and damage they cause.

In integrated plant production, the integrated production notebook serves as the record-keeping tool.

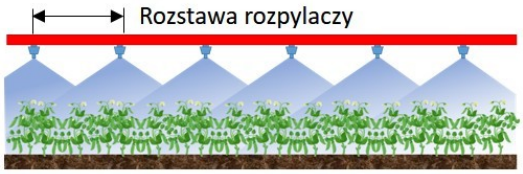
Filling the mandatory IP notebook in the system of integrated plant production fulfils the requirement to keep the above-mentioned documentation for certified crops. Documentation rules will change on 1 January 2026 as a result of the application of Implementing Regulation (EU) 2023/564.

Table 5. Procedure and table for recording the results of field sprayer calibration

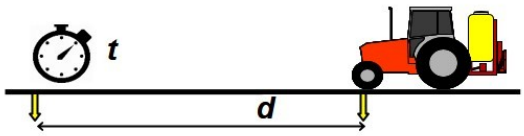
KALIBRACJA OPRYSKIWACZA POLOWEGO

1. Określ wymaganą **dawkę cieczy** w zależności od rodzaju zabiegu, fazy wzrostu roślin i typu opryskiwacza.

2. Sprawdź **rozstawę rozpylaczy** na belce opryskiwacza polowego.



3. Wyznacz **prędkość roboczą** opryskiwacza na podstawie pomiaru czasu przejazdu ***t*** na odcinku drogi o znanej długości ***d***.



$$\text{Prędkość [km/h]} = \frac{\text{Długość odcinka pomiarowego } \mathbf{d} \text{ [m]}}{\text{Czas przejazdu } \mathbf{t} \text{ [sek]}} \times 3{,}6$$

Czas sek/100 m	45	48	**50**	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	85	90
Prędkość km/h	8,0	7,5	**7,2**	6,9	6,7	6,4	6,2	6,0	5,8	5,6	5,5	5,3	5,1	5,0	4,9	4,7	4,5	4,4	4,2	4,0

4. Oblicz **jednostkowy wydatek rozpylaczy** potrzebnych do realizacji wyznaczonej **dawki cieczy** przy obliczonej **prędkości roboczej**

$$\text{Wydatek [l/min]} = \frac{\text{Dawka [l/ha]} \times \text{Rozstawa rozpylaczy [m]} \times \text{Prędkość [km/h]}}{600}$$

5. Z tabeli wydatków nominalnych wybierz **rozpylacze** i **ciśnienie cieczy**, dla których wydatek jednostkowy jest najbliższy obliczonemu jak powyżej.

6. Zamontuj wybrane rozpylacze, uruchom opryskiwacz i ustaw nominalne ciśnienie, odczytane w tabeli wydatków.
Przy użyciu wyskalowanego naczynia zmierz w ciągu minuty wydatek kilku rozpylaczy na każdej sekcji i w razie niezgodności wyniku z wydatkiem wymaganym skoryguj ciśnienie i powtórz pomiar.

7. Zapisz wszystkie uzyskane wyniki kalibracji w tabeli.

DAWKA CIECZY l/ha	ROZPYLACZE		CIĄGNIK		POMIAR PRĘDKOŚCI		PRĘDKOŚĆ	WYDATEK	CIŚNIENIE
	Rozstawa m	Typ Rozmiar	Bieg	Obroty obr/min	Odcinek m	Czas s	km/h	l/min	bar

KALIBRACJA OPRYSKIWACZA POLOWEGO	FIELD SPRAYER CALIBRATION
Określ wymaganą **dawkę cieczy** w zależności od rodzaju zabiegu, fazy wzrostu roślin i typu opryskiwacza.	Determine the required **dose of liquid** depending on the type of treatment, the growth phase of plants, and the type of sprayer.
Sprawdź **rozstawę rozpylaczy** na belce opryskiwacza polowego.	Check **the sprayer spacing** on the boom of the field sprayer.
Wyznacz **prędkość roboczą** opryskiwacza na podstawie pomiaru czasu przejazdu **t** na odcinku drogi o znanej długości ***d.***	Determine the**working speed** of the sprayer based on the measurement of travel time **t** on a known distance ***d.***
Prędkość [km/h] -	*Speed [km/h] =*
*Długość odcinka pomiarowego **d** [m] Czas przejazdu **t [**sek]*	*Measuring distance **d** [m] Travel time **t [**sec]*
Czas sek/100 m	**Time** sec/100 m
Prędkość km/h	**Speed** km/h
Oblicz **jednostkowy wydatek rozpylaczy** potrzebnych do realizacji wyznaczonej **dawki cieczy** przy obliczonej **prędkości roboczej**	Calculate **the unit discharge of sprayers** necessary for the implementation of the designated **liquid dose** at the calculated **operating speed**
Wydatek [l/min] =	*Discharge [l/min] =*
Dawka [l/ha] x Rozstawa rozpylaczy [m] x Prędkość [km/h]	*Dose [l/ha] x Sprayer spacing (m) x Speed (km/h)*
Z tabeli wydatków nominalnych wybierz **rozpylacze** i **ciśnienie cieczy,** dla których wydatek jednostkowy jest najbliższy obliczonemu jak powyżej.	From the table of nominal discharges, select **sprayer** and **liquid pressure,** for which the unit discharge is closest to the one calculated above.
Zamontuj wybrane rozpylacze, uruchom opryskiwacz i ustaw nominalne ciśnienie, odczytane w tabeli wydatków.	Install the selected sprayers, start the sprayer, and set the nominal pressure as indicated in the expenditure table.
Przy użyciu wyskalowanego naczynia zmierz w ciągu minuty wydatek kilku rozpylaczy na każdej sekcji i w razie niezgodności wyniku z wydatkiem wymaganym skoryguj ciśnienie i powtórz pomiar.	Using a calibrated vessel, measure within a minute the discharge of several sprayers on each section and, in the event of non-conformity of the result with the required discharge, adjust the pressure and repeat the measurement.
Zapisz wszystkie uzyskane wyniki kalibracji w tabeli.	Record all obtained calibration results in the table.
DAWKA CIECZY l/ha	LIQUID DOSE l/ha
ROZPYLACZE	SPRAYERS
Rozstawa m	Spacing m
Typ Rozmiar	Type Size
CIĄGNIK	TRACTOR
Bieg	Run
Obroty obr/min	RPM
POMIAR PRĘDKOŚCI	SPEED MEASUREMENT
Odcinek m	Section m
Czas s	Time s
PRĘDKOŚĆ km/h	SPEED [km/h] =
WYDATEK l/min	DISCHARGE [l/min] =
CIŚNIENIE bar	Pressure bar

X. HYGIENIC AND SANITARY PRINCIPLES

During harvest and the preparation of crops produced under integrated plant production for sale, the producer ensures that the following hygienic and sanitary principles are followed.

Personal hygiene of employees during harvesting

- they must not be carriers of, or have diseases transmissible through, food;
- maintain personal cleanliness, observe hygiene rules and in particular wash hands frequently at work;
- wear clean clothing and, where necessary, protective clothing;
- apply watertight dressings to skin cuts and scratches.

The producer should provide staff working at harvesting and preparation of fruit for sale with:

- unlimited access to washbasins and toilets, cleaning products, paper towels or hand dryers, etc;
- training in hygiene.

Hygiene requirements for crops prepared for sale.

A plant producer shall take appropriate measures to ensure that:

- the use of clean water or water of the class intended for consumption to wash agricultural produce as required;
- protection of crops during and after harvesting against physical, chemical and biological pollution.

Hygiene requirements for packaging and means of transport and places for preparing crops for sale.

A producer shall take appropriate measures to ensure:

- that rooms (and equipment), means of transport and packages are clean;
- maintaining order on driveways and around buildings where merchandise is stored and prepared for trade;
- farmed and domestic animals have no access to the rooms, vehicles and packaging;
- 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;
- hazardous waste and substances are not stored together with crops prepared for sale.

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

Model notebooks are included in the Annex to Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on documenting activities related to integrated plant production (Journal of Laws of 2023, item 2501).

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

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

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

The application form should be completed with information such as:

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

The application must also include the date and signature of the applicant. The 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 rotation shall be reported for the period (number of years) specified in the methodology.

Seed (...) - complete the table by entering information about the purchased seed – variety, category, degree of qualification, quantity, and proof of purchase (invoice, official label combined with a plant passport, or marketing label and plant passport).

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

Soil/substrate and plant analysis and fertilisation/fertigation — soil analysis is a fundamental activity to determine the fertiliser needs of plants. The IP producer must carry out such analyses and record them in the notebook. The field code, the type or scope of testing and the number and date of the report should be entered in the 'Soil and plant analysis' table. All organic fertilisers applied should be recorded in the 'Organic fertilisation

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

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

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

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

The Notebook also has a space for comments and own notes and a list of appendices. It is possible for an agricultural producer to obtain an IP certificate by applying to a certification body. Forms for the relevant applications are available from the certification bodies. Along with the completed application for a certificate certifying the use of integrated plant production, the plant producer shall provide the certifying operator with a statement

that the crop was carried out in accordance with the requirements of integrated plant production and information on the species and varieties of plants grown using the requirements of integrated plant production, the area of their cultivation and the yield size.

XII. GENERAL RULES FOR ISSUING CERTIFICATES IN INTEGRATED PLANT PRODUCTION

The intention to use integrated plant production shall be notified annually by the producer concerned to the certification body **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 inspects plant producers that follow the principles of integrated plant production. Supervisory actions cover in particular:

- the completion of IP training;
- compliance with production methods approved by the Main Inspector of Plant Health and Seed Inspection;
- compliance of fertilisation with the food requirements of the crop;
- carrying out plant protection in accordance with the principles of Good Plant Protection Practice
- documentation;
- following hygiene and health principles;
- collection of samples and control of highest tolerable plant protection product residues as well as of nitrate, nitrite and heavy metal levels in plants and plant products.

The plants or plant products of no less than 20 % plant producers entered in the register of producers maintained by the certifying authority are subjected to tests for the maximum permissible residue levels of plant protection products and levels of nitrates, nitrites and heavy metals in plants, starting with plant producers who are suspected of not following the requirements of Integrated Plant Production.

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 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*, as amended. They should seek to reduce and minimise residues by extending the period between the application of pesticides and harvest. The currently applicable values of maximum residue levels of

pesticides in the European Union are published on the following website: 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 application of integrated plant production is issued if the crop producer meets the following requirements:

1) has completed training in Integrated Plant Production and has a relevant certificate to confirm this, subject to Article 64(4), (5), (7) and (8) of the Plant Protection Products Act;
2) conducts production and protection of plants according to detailed methodologies approved by the Main Inspector and made available on the website managed by the Main Inspector of Plant Health and Seed Inspection;
3) applies fertilisation based on the actual demand of plants for nutrients, determined in particular on the basis of soil or plant analyses;
4) documents the correct conduct of activities related to Integrated Plant Production;
5) complies with hygiene and health rules with respect to the production of plants, in particular those specified in the methodologies;
6) in samples of plants and plant products taken for testing, the use of unrecommended plant protection products and exceeding the maximum residues of these products and the levels of nitrates, nitrites and heavy metals were not found;
7) in the production of plants, they follow the requirements of plant protection against harmful organisms, as described in the relevant methodologies.

The certificate confirming the application of Integrated Plant Production is issued for the period necessary for the sale of plants, but not longer than for 12 months. A plant producer who has received a certificate confirming the application of Integrated Plant Production may use the Integrated Plant Production Mark for the designation of plants for which this certificate was issued. A model of the mark is provided by the Main Inspector at the website of the Main Inspectorate of Plant Health and Seed Inspection.

XIII. LIST OF OBLIGATORY ACTIVITIES AND TREATMENTS IN THE INTEGRATED PRODUCTION SYSTEM OF FIELD PEA (SUGAR AND SHELLING)

Mandatory requirements (100% compliance, i.e. 13 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Not growing field pea and other plants of the Fabaceae family in the same field more frequently than every 4 years (see chapter II 2.1).	❑/❑	
2.	Making winter ploughing in the autumn period (see chapter II 2.2).	❑/❑	
3.	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 2.5).		
4.	Seed must be used for sowing at least in the standard category – labels and proof of purchase of seed must be kept (see Annex 1).	❑/❑	
5.	Monitoring of field pea plants at least once a week for the presence of the following diseases: ascochyta blight, grey mould, powdery mildew, and downy mildew (see chapter V 5.2, Annex 1).	❑/❑	
6.	Prophylactic/interventional control of ascochyta blight, grey mould, powdery mildew, and downy mildew only after the risk of infection has been established on the basis of an analysis of weather conditions and/or after the onset of the first symptoms (see chapter V 5.2, Annex 1).	❑/❑	
7.	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. 5.6).	❑/❑	
8.	Conducting monitoring of pea plantations for the presence of pea aphids (once a week) (see chapter VI).	❑/❑	
9.	Including in the pest and pathogen protection programme of plants of non-chemicals (at least one of the treatments performed should be made with such a preparation) (see chapter III; VI 6.2).	❑/❑	
10.	Recognition of weed species in the field designated for the cultivation of pea, in the year preceding its cultivation, and entering their names in the notebook of integrated production (see chapter IV).	❑/❑	
11.	Mowing of uncultivated land around plantations belonging to the same holding (e.g. margins, ditches, roads) at least twice a year to prevent weeds from releasing seeds (see chapter IV 4.1).	❑/❑	
12.	Placing shelters for mason bees or bumblebees in the number of at least 1 per 5 ha, and for larger plantations – several pieces (see: chapter VI 6.5).	❑/❑	
13.	Creating suitable conditions for the presence of birds of prey by setting up at least 1 rest pole per 5 ha, and for larger plantations — several poles (see chapter VI 6.4).	❑/❑	

NOTE! The fulfilment of all the requirements in the list of mandatory activities and treatments under the integrated production system must be documented in the Integrated Plant Production Notebook.

XIV. 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 Main 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 Plant Protection Products Act?	❑/❑	
3.	Does the producer apply plant protection products only from the list of IP-recommended products?	❑/❑	
4.	Are all required documents (e.g. methodologies, notebooks) present and kept on the farm?	❑/❑	
5.	Is the IP Notebook kept correctly and up to date?	❑/❑	
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 risk 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 approved for use in the plant?	❑/❑	

12.	Is every use of plant protection products recorded in the IP Notebook, taking into account the reason of the application, the date and place of application, the cultivation area, the dosage of the preparation, and the amount of the spray liquid per unit area?	❑/❑	
13.	Have the plant protection treatments been 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 grace periods observed?	❑/❑	
20.	Are the doses and the maximum number of treatments during the growing season specified on the label of the plant protection product not exceeded?	❑/❑	
21.	Are the sprayers listed in the IP Notebook tested and operational?	❑/❑	
22.	Does the manufacturer conduct 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 the plant protection products stored only in 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?	❑/❑	
	Total points		

Additional requirements for open-field vegetable crops (at least 50 % compliance i.e. 11 points)			
Item	**Checkpoints**	**YES/NO**	**Comment**
1.	Were the plant varieties grown selected for Integrated Plant Production?	❑/❑	
2.	Is each box marked according to the entry in the IP notebook?	❑/❑	
3.	Does the producer use the correct crop rotation?	❑/❑	
4.	Did the producer perform all the necessary agrotechnical procedures in accordance with IP methodologies?	❑/❑	
5.	Does the seed used (seeds, seedlings) meet the production and quality requirements and have documents – label/plant passport, marketing label?	❑/❑	
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.	Have the procedures been conducted using spraying devices specified in the IP notebook?	❑/❑	
10.	Are protective clothing and health and safety rules observed during spraying 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		

XV. LITERATURE

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ANNEXES

Annex 1.

Combating the most important diseases in the integrated production of field pea

Disease	**Times of treatments and comments**
Bacterial blight of pea	• Sow seed of at least standard category. • Observe plant health in a given growing season at least once a week. • Avoid frequent sprinkling of crops at high temperatures, mainly at night. Use plant protection products authorised for IP. Remove plants with disease symptoms.
Ascochyta blight of pea	• At the time of danger or the appearance of the first signs of disease, it is recommended to carry out variable spraying of pea plants with fungicides, with different mechanisms of action, registered for IP. • Registered non-chemical preparations should be included in the protection programme. • Sow seed of at least standard category. • Observe plant health in a given growing season at least once a week.
Powdery mildew of pea	• • Observe plant health in a given growing season at least once a week. • At the time of danger or the appearance of the first signs of disease, it is recommended to carry out variable spraying of pea plants with fungicides, with different mechanisms of action, registered for IP. • Registered non-chemical preparations should be included in the protection programme. • Plants should not be grown in excessive density.
Fusarium wilt of pea	Incidence of the disease can only be prevented by: observing a break of several years in pea cultivation (4 years) in the same field. • Cultivation on very wet soils and soils with water residues should be avoided, • Deep tillage (with a subsoiler up to 40 cm) should be performed before sowing.
White mould	• Observe the correct rotation and avoid growing after plants of the family Fabaceae. • Before sowing the crop, about 10-30 days apply a soil spray with an approved biological product. • It is recommended to alternate spraying of pea plants with fungicides with different mechanisms of action, registered for IP.
Grey mould	• During periods favourable to the development of the disease or

	when the first symptoms of the disease are noticed, it is advisable to spray pea plants with fungicides registered for IP.
Seedling blight	• • Sowing of 'certified' or 'standard' seed into a substrate free of pathogens. • Pea seeds should be treated with fungicides as a precaution. • Under unfavourable weather conditions, i.e. low temperatures and rainfall, the sowing date of the seeds should be delayed as an excessively long germination period promotes seedling infection.
Downy mildew	• The first treatment should be performed prophylactically or when the first symptoms appear. • Observe plant health in a given growing season at least once a week. • At the time of danger or the appearance of the first signs of disease, it is recommended to carry out variable spraying of pea plants with fungicides, with different mechanisms of action, registered for IP.

Annex 2.

Thresholds for pests occurring on pea

Pest species	**Risk threshold**	**Time of inspection and controlling**	**Harmful stage**
flies	finding more than 10 % of destroyed plant emergences in the year preceding the crop	monitoring to be carried out during the period of germination and emergence.	larvae
weevil	10 % of plants with damaged leaves at the 2-3 leaf stage.	Monitoring of the plantation should be carried out from the emergence of pea, searching for plants with signs of damage. Chemical control should be conducted until the end of leaf development upon noticing beetles or damage.	beetles and larvae
pea midge	finding between 25 and 30 egg deposits on the tops of shoots per 1 m^2 of crop	monitoring should begin during the formation of flower buds. During the monitoring, examining the plants, paying attention to the appearance of shoots in the apical part. Combating should begin at the stage of formation of the first pods.	larvae

pea moth	finding an average of 1 egg deposit per 10 plants	begin control measures 7-10 days after observing the first moths in pheromone traps.	caterpillars
caterpillar that damage the leaves	detection of 2-3 caterpillars on 10 consecutive plants or per m^2 of cultivation	monitoring to be conducted from May to June. Bacterial preparations are best used during the younger developmental stages of caterpillars.	caterpillars
pea aphid	5 aphids per plant in the phase up to 15 cm in height, on the apical parts of the shoots	crop monitoring should be conducted since the beginning of May. Fighting should commence once the threat threshold is exceeded.	larvae and adults
thrips	20 larvae and female thrips in 10 inflorescences.	monitoring should be conducted since the beginning of May. Blue sticky boards can be used to monitor the flight of thrips. The optimal time for pest control is the period of flowering and the formation of the first pods	larvae and adults
Lygus pratensis	more than 2 individuals per 1 m^2 of crops, in 8 to 10 outer rows.	Monitoring should be conducted during flowering and bud formation. Chemical protection is mainly recommended in the cultivation of dry seeds until the pods reach their typical length and the seeds are completely formed.	larvae and adults
pea weevil	seed inspection in storags: detection in February of 1 beetle in 1 kg of seeds in 3 samples taken at random from 100 kg of seeds in the field: 3-5 beetles per 15-20 m^2 of the fringe rows of plantations	field monitoring should begin in May (beginning of pod setting); in storage – storage period of the seeds. In field, perform the treatment after the occurrence of the pest.	larvae