MAIN INSPECTORATE OF PLANT HEALTH AND SEED INSPECTION

PIORIN

Draft

Integrated Production Methodology of field bean

(*Vicia faba*)

(first edition)

Approved
pursuant to Article 57(2)(2) of the Act of 8 March 2013 on plant protection products
(consolidated text Journal of Laws of 2024, item 630)

by

the Main Inspector of Plant Health and Seed Inspection

Warsaw, November 2024

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INTEGRATED PRODUCTION
OFFICIALLY CONTROLLED

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1. INTRODUCTION

Integrated plant production (IP) is a management system that takes into account the use of technology and biological progress in a sustainable manner in the cultivation, protection and fertilisation of plants while ensuring the safety of the natural environment. The essence of integrated plant production is therefore obtaining crops satisfactory for both producers and consumers, in a way that does not interfere with the protection of the environment and human health. Its strategy is more complicated than that of production using conventional methods. As much as possible, natural biological mechanisms supported by the rational use of plant protection products are used in the integrated plant production process. In modern agricultural production technology, the use of fertilisers and plant protection products is necessary and extremely beneficial, but at times it may also threaten the environment. In integrated plant production, however, special attention is paid to the reduction of the role of plant protection products used to limit pests to a level that does not threaten crops, fertilisers and other necessary resources needed for plant growth and development to create an environmentally safe system while ensuring high-quality crops free from residues of substances known to be harmful (heavy metals, nitrates, plant protection products).

2. LEGAL REGULATIONS IN FORCE IN INTEGRATED PRODUCTION (IP) AND THE PRINCIPLES OF ITS CERTIFICATION

2.1. Integrated pest management as the foundation of integrated production (IP)

Integrated pest management consists in protecting crops against harmful organisms using all available methods, in particular non-chemical methods, in a way that minimises risks to human, animal and environmental health.

Integrated protection consolidates and systematises practical knowledge about organisms harmful to plants (especially about their biology and harmfulness), in order to determine optimal deadlines for taking action to combat these organisms while taking into account naturally occurring beneficial organisms, i.e. predators and parasites of organisms harmful to plants. It also reduces the use of chemical plant protection products to a necessary minimum, thus reducing environmental pressure and protecting the biodiversity of the agricultural environment.

Professional users who use plant protection products are obliged to take into account the requirements of integrated plant protection set out in the Regulation of the Minister for Agriculture and Rural Development of 18 April 2013 on requirements for integrated plant protection (Journal of Laws of 2013, item 505). According to the aforementioned Regulation, an agricultural producer should use all available measures and methods of protection against pests before applying chemical plant protection to reduce the use of pesticides. The provisions of this Regulation put a strong emphasis on, inter alia, the use of crop rotation, suitable varieties, compliance with optimal deadlines, the use of appropriate agrotechnology, fertilisation, and prevention of the spread of harmful organisms. One of the requirements is also the protection of beneficial organisms and the creation of favourable conditions for their occurrence, in particular pollinating insects and natural enemies of harmful organisms. The use of chemical plant protection should be preceded by monitoring activities and supported by appropriate scientific instruments and advice.

According to the current legal provisions, only plant protection products authorised on the basis of authorisations (or parallel trade permits) issued by the Minister for Agriculture and Rural Development may be used for chemical protection of plants.

The list of plant protection products authorised in Poland is published in the relevant register. Information on the scope of application of pesticides in individual crops is included on the labels. The Ministry of Agriculture and Rural Development provides a register and labels at: https://www.gov.pl/web/rolnictwo/ochrona-roslin.

Information on plant protection products authorised for integrated production is published in the Online Pest Warning System at: https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.

Before the application of a plant protection product, it is the responsibility of each user to read and follow the label.

In accordance with the Regulation of the Minister for Agriculture and Rural Development of 31 March 2014 on conditions of use of plant protection products (Journal of Laws of 2014, item 516) pesticides may be applied in the open area using:

- ground equipment at a distance of at least 20 m from the apiaries;
- field sprayers at a distance of at least 3 m from the edge of the roadway of public roads, excluding public roads falling within the category of municipal and district roads;
- field sprayers at a distance of at least 1 m from reservoirs and watercourses and non-agricultural areas other than those treated with plant protection products.

When using plant protection products, the label of the products should be read in detail, as it may contain additional conditions limiting its applicability.

In accordance with the legislation in force, any use of a plant protection product must be registered. The professional user is obliged to maintain and store for 3 years documentation containing the name of the plant protection product, the time of use and the dose applied, the area or surface area or unit of weight of the grain and cultivation or the facilities on which the plant protection product has been applied. The law also requires the method of fulfilling the requirements of integrated pest management to be indicated in the documentation by providing at least the reason for the treatment with a plant protection product. Filling the mandatory IP notepad in the system of integrated plant production fulfils the requirement to keep the above-mentioned documentation for certified crops.

For treatment with plant protection products, equipment intended for that purpose shall be used which, when used for its intended purpose, does not pose a risk to human health, animal health or the environment and is technically efficient and calibrated to ensure the correct use of plant protection products. Owners of equipment for the use of plant protection products are obliged to carry out periodic tests confirming technical fitness. The first inspection of new equipment is conducted no later than after 5 years from the date of its purchase. Tractor and self-propelled field sprayers shall be inspected at intervals of no more than 3 years. Manual and backpack sprayers whose tank capacity does not exceed 30 litres are excluded from the test obligation.

2.2. Integrated plant production in legislation

In the IPM certification scheme, all legal requirements for plant protection products must be respected, with particular regard to the principles of IPM.

2.3. Principles of certification

The basic requirement for the possibility of growing crops in the system of integrated plant production and obtaining an IP certificate is to submit a notification to the entity certifying integrated plant production.

The notification of the intention to use integrated plant production shall be made annually by the plant 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.

After the notification, the agricultural producer is obliged to grow according to the method of integrated plant production for the notified plant and to document the activities in the IP Notebook in detail. Model notebooks are included in the Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on documenting activities related to integrated plant production.

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

- completion of IP training;
- production in accordance with the methodologies approved by the Main Inspector of Plant Health and Seed Inspection;
- fertilisation;
- 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 maximum permitted plant protection product residue content and nitrate, nitrite and heavy metal levels in plants are tested in the plants or plant products of no less than 20 % of the growers listed in the grower register held by the certification body, starting with any growers suspected of not following integrated plant production principles. The tests shall be carried out in laboratories accredited in the relevant area.

A certificate issued at the request of the grower attests that integrated plant production principles are followed. The producer shall be certified if it has complied with the following requirements:

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

Integrated pest management certificates are issued for the period necessary for the plant product to be disposed of, but no longer, however, than 12 months.

Growers who have been granted a certificate attesting that they follow integrated plant production principles may use the Integrated Plant Production mark to distinguish the plants for which the certificate has been issued. A sample mark is provided by the Main Inspector on the website of the Main Inspectorate of Plant Health and Seed Inspection.

3. CLIMATE AND SOIL REQUIREMENTS, AND SITE SELECTION

3.1. Site

Field bean (*Vicia faba*) is a long-day plant, well adapted to Polish climatic conditions. Favourable thermal conditions prevail throughout the country, and the cultivation regions of this species are determined by the soils, as on compact clay soils with a deep accumulation level, there is a possibility of an adequate supply of water to the field bean.

Of all the species of coarse-seeded Fabaceae grown in Poland, field bean has the highest water requirements. The transpiration rate for this species ranges from 500 to 700. The optimum rainfall for field bean is 320–400 mm, while for medium soils it is 347 mm and for heavy soils it is 304 mm. The greatest water needs of this species occur during the period of intensive growth, flowering and pod setting. This occurs between mid-June and mid-July. It reacts negatively not only to water scarcity in the soil, but also in the air. A drought occurring during this period causes a shortening of the length of the fruiting part of the shoot, a reduction in the number of pods on the plant, and a decrease in the weight of the seeds, which leads to a decrease in yield (Księżak 2018a, b, Księżak et al. 2018). Excessive rainfall during the ripening of seeds and the drying of stems and pods is unfavourable, as it prolongs the growing season and makes harvesting more difficult.

3.2. Soil

This species has high soil requirements and thrives best in dense, fertile, moisture-retentive soils of high quality, classified as very good and good wheat complex (classes I to IIIb). These include chernozems, black soils, brown and lessive soils developed from loams and boulder clays, medium and heavy alluvial soils. In conditions of good moisture content and appropriate soil cultivation, a high level of yield can also be obtained on class IVa soils. Field bean requires more compact, structural, and humus-rich soils with a neutral pH. However, dry and excessively moist soils are unsuitable for cultivation, as they hinder the development of the root system and rhizobacteria. Field bean requires soils with a neutral and alkaline reaction, and does not tolerate heavily acidified ones. The optimum pH ranges from 6.8 to 7.2.

3.3. Precursor crop

The best precursor crop for field bean is cereals, both in their winter and spring forms. A good precursor crop for field bean includes winter and spring oilseed rape, mustard, and maize. When growing field bean after maize, it is required to pay attention to the active substances of herbicides to prevent damage to the crop. When establishing a field bean plantation after brassica plants, it is necessary to combat their self-sowns before establishing a plantation. In integrated production, field bean must not be grown directly after root crops, both tuberous and root vegetables. The interval in the cultivation of field bean after fertilisation with manure, for all Fabaceae, and root crops is a minimum of 4 years. In the cultivation of field bean after cereals, it is recommended to grow stubble crops; however, these must not include Fabaceae (the cultivation of stubble crops is not a mandatory requirement). Examples of catch crops before sowing field bean are: white mustard, blue tansy, common sunflower, oilseed radish, and stubble turnip. Placing field bean in too close a succession after manure causes excessive vegetative development of plants, which prolongs ripening and reduces seed yield. In the same field, it can be grown every 4 years, and its share in the seeding structure cannot be greater than 20–25 %. Field bean should not be grown after Fabaceae in pure sowing, as well as after their mixtures with grasses and after alternating pastures. This species is a valuable precursor crop for cereals, especially for winter wheat. The yield of spring and winter cereals following field bean with traditional development and determinate growth type was the same or higher by 6-11 % compared to after oats. This species causes multiple changes in soil chemistry and biology, which directly and indirectly affect the increase in soil fertility. Its importance is growing in farms specializing in the cultivation of cereals, where it also acts as a phytosanitary plant (Księżak and Kuś 2005).

4. SELECTION OF FIELD BEAN VARIETIES IN INTEGRATED PRODUCTION

Field bean is a very valuable plant, especially on compact soils, adapted to cultivation in the climatic conditions of Poland. Among the coarse-seeded Fabaceae grown in our country, it has the greatest soil and water requirements, and this fact determines the areas of its cultivation (in the northern and southern belts). Compensation for high requirements is the largest protein yield in the coarse-seeded Fabaceae group. Despite its qualities, it is a species that has been underestimated for many years. One of the reasons for this situation may be that growing field bean in conditions that meet its requirements is not always easy. Intensive plant growth and the possibility of lodging and uneven ripening make it difficult to perform protection treatments during the growing season. If, on the other hand, field bean is sown on the wrong site (too light soils, areas with periodic shortage of rainfall), its high yield potential is clearly limited.

The main purpose of its cultivation in Poland is the production of feed seeds. For this reason, the chemical composition of field bean seeds is considered in terms of nutritional value and their usefulness in the composition of feed. Of particular importance is the information on anti-nutritional components in seeds, especially tannins, which are undesirable and limit the share of seeds in feed.

Trends in breeding new varieties are a response to the demand reported by agricultural practice. It is therefore important to breed varieties of different types, taking into account the specific requirements of feed users and producers. The final verification of the achieved breeding success is the dissemination of the variety in cultivation and its large and constant share in reproduction.

In the past, field bean varieties with a non-determinate growth type and seeds containing tannins in concentrations close to 1.0 mg/g d.m. were generally bred and grown. Later, breeding work was carried out in the following directions: the development of determinate varieties and varieties with a low tannin content in the seeds. On the one hand, evenly ripening forms with shorter plants were sought to facilitate care treatments, and on the other hand, the chemical composition of seeds needed improvement—mainly by reducing the content of anti-nutritional compounds.

Bean varieties are grouped on the basis of essential morphological and utilitarian differences. Currently, three groups of field bean varieties are distinguished in the National Register (KR): non-determinate with a significant tannin content in seeds, non-determinate with a low tannin content (so-called low-tannin) in seeds, and determinate varieties with a significant tannin content.

The basic principle is the use of seed of at least the certified category. The variety used should be entered in the national register or in the Community catalogue of varieties.

Detailed rules for the selection of varieties in integrated plant production are published on the dedicated COBORU website.

Detailed information on the selection of varieties recommended for IP by COBORU can be found in the list on the website coboru.gov.pl/pdo/ipr.

5. PRE-SOWING TILLAGE AND SOWING

5.1. Soil cultivation

After harvesting the precursor crop, disc harrowing should be done. After early harvesting of cereals, stubble crops (brassica plants or phacelia) should be sown. Before winter, the soil should be ploughed, preferably with a reversible plough, as this leaves no furrows, reduces the passages on headlands, and lowers the cost of the treatment.

The purpose of spring cultivation is to prepare a good substrate for the seeds to be sown (8–12 cm deep) and to reduce the number of cultivation operations carried out during this period. A decrease in field bean yield is observed after frost-damaged winter crops, while direct sowing under irrigation conditions reduces the yield of field bean seeds compared to plough cultivation by 11 to 14.4 %, and under natural soil moisture conditions by 9.3 % to 13.6 %. On heavy soil, the yield of field bean is more influenced by weather conditions during the growing season than by diversified farming. Cultivation procedures depend on the method of sowing seeds and the condition of the soil after winter. Sowing with a seedbed cultivator allows the sowing of field bean in one pass of the tractor. When using a seed drill with disc coulters intended for deep sowing, a tillage unit should be used before sowing. Usually, cereal seed drills do not have disc coulters and are not suitable for sowing field bean, as they are not able to place seeds at a depth of 8–12 cm. Field bean seeds can be sown to the correct depth and evenly distributed in a row using precision seed drills, provided that the row spacing is about 30 cm.

5.2. Sowing

Seed of at least the certified category, with a known use value and a weight of 1000 seeds, shall be used for sowing. This will allow for the determination of the correct amount of sowing to ensure the proper density of the crop stand. The period from sowing to emergence is long and during this time the seeds are infested by fungi found in the soil.

Immediately before sowing, in order to increase the degree of nodulation and assimilation of nitrogen from the air, the seeds should be inoculated.

Field bean should be sown as early as possible to utilize good soil moisture for seed germination. The low temperature in the initial period of growth allows for complete vernalization in a short time, developing a stronger root system that ensures a better supply of nutrients and water to the plant. The delayed sowing period largely determines the number of pods and seeds on the plant, the weight of 1000 seeds, and, as a result, the level of yield. Early sowing also affects the earlier blooming of plants and the lower formation of whorls of the first inflorescences, which are better supplied with assimilates and water than inflorescences located higher. The desirability of using an early sowing date is justified by high sensitivity to weather factors – temperature plays a large role in shaping the length of the growing season of field bean. Each day of delay in sowing in the period from 30 March to 14 April reduces the number of pods and seeds on the plant and, as a result, decreases the yield of field bean seeds by about 0.8 % (about 35 kg/ha) and slightly shortens the shoots. The delay in sowing also prolongs the ripening period of the plants, worsens the conditions for their harvesting and drying of the seeds.

Ensuring optimal plant density per unit area in accordance with the recommendations for the selected variety is one of the most important agrotechnical factors determining the yield of field bean seeds. In addition, the number of plants per unit area has a significant impact on proper generative development, maintenance of weed-free plantations, and even ripening of plants. The risk of their lodging and the occurrence of diseases and pests is also reduced.

The amount of sowing depends on the germination capacity and the weight of 1000 seeds. The required amount of sowing per 1 ha is calculated according to the formula:

$$\textbf{sowing quantity} = \frac{\mathbf{a \times b}}{\mathbf{c}}$$

where:

a - number of seeds per 1 m^2

b - weight of 1000 seeds in g

c – use value of the seed in % $\left(\frac{\text{purity \% x germination capacity \%}}{100}\right)$

The recommended row spacing is 20-30 cm, and the optimum sowing depth is 8-12 cm. Seeds should be sown more shallowly on compact, fertile, and moist soils, and deeper on lighter and drier soils. Seeds placed at this depth have good conditions for germination, and seedlings for the development of the root system. The plants are then more resistant to drought and lodging, and it is possible to mechanically and chemically control weeds.

Due to the need to apply spraying during the growing period of the field bean, it is necessary to designate traverse paths with a width of 40-45 cm for the wheels of the spraying unit, at intervals adapted to the width of the equipment used.

6. SUSTAINABLE FERTILISATION SYSTEM FOR FIELD BEAN

In integrated production, fertilisation is determined on the basis of a nutrient balance before each crop, and soil testing is conducted at least every 4 years (and confirmed by documents).

The effectiveness of the cohabitation of field bean with rhizobacteria and the proper use of nutrients is determined by the soil pH. Acid soils with a pH below 5.5 should preferably be limed during post-harvest cultivation treatments after the precursor crop (tab. 1). If the magnesium content is less than 6 mg per 100 g of soil, magnesium lime should be used. Magnesium fertilizers of 40–80 kg/ha MgO should be applied to soils with a pH close to neutral but low in magnesium.

Table 1. Calcium fertiliser doses in t /ha

Soil complex	Liming requirements			
	necessary	needed	recommended	limited
Wheat: very good and good	6.0	3.0	2.0	1.0
Rye: very good	4.5	3.0	1.7	1.0
Wheat defective Rye good	3.5	2.5	1.5	-

Field bean has relatively high nutritional requirements, as it takes 2-3 times more nutrients per unit of yield than cereals (Księżak 2007). However, its root system is capable of extracting nutrients from compounds in hard-to-reach forms. This is explained by the frequent lack of reaction of field bean to phosphorus and potassium fertilisation on soils with an average abundance of these components (Księżak and Kęsik 2017; Podleśna 2015). The recommended doses of phosphorus and potassium fertilizers depend on the soil's abundance of these components (tab. 2 and 3) and on the level of the expected yield. These fertilizers should be applied before winter ploughing or as early as possible in the spring before the start of spring work.

Table 2. Phosphorus fertiliser doses (kg P_2O_5/ha)

Soil complex	Phosphorus content				
	very low	low	medium	high	very high

Wheat very good Wheat good Strong cereal-legume fertiliser	115	75	45	35	30
Rye: very good	125	85	50	35	30
Wheat defective Rye good	100	70	45	25	20

Table 3. Potassium fertiliser doses (kg K_2O/ha)

Soil complex	Potassium content				
	very low	low	medium	high	very high
Wheat very good Wheat good Strong cereal-legume fertiliser	130	105	95	85	25
Rye: very good	135	125	105	95	30
Wheat defective Rye good	105	105	90	75	30

Thanks to its symbiosis with rhizobacteria, field bean, like other Fabaceae, utilises atmospheric nitrogen (Martyniuk 2012). Nevertheless, the beneficial effect of mineral nitrogen on the yield of field bean seeds is emphasised, which is mainly expressed by an increase in the number of pods and seeds per pod. Increasing nitrogen fertilisation doses increase the protein content of seeds, with foliar nitrogen feeding having a more beneficial effect on this characteristic. In soils rich in nitrogen (after plants heavily fertilised with this component or ploughed stubble crop), and especially in conditions of good soil moisture, nitrogen fertilisation is unnecessary. In weaker sites, a starting dose of nitrogen (20-30 kg/ha N) should be applied, which plants can utilize during the initial growth period, when root nodules have not yet developed. Excessive doses of nitrogen have an adverse effect on the efficiency of the symbiosis between plants and rhizobacteria. Field bean, like all Fabaceae, also has higher requirements for some micronutrients: molybdenum, manganese, cobalt, zinc, and boron. If the condition of the plants indicates nutrient deficiencies (e.g. chlorosis), multi-component foliar fertilisers should be applied – especially on neutral soils, where elements such as manganese and boron pass into forms that are hardly soluble and inaccessible to plants (Jarecki and Bobrecka-Jamro 2014).

7. INTEGRATED PROTECTION AGAINST PESTS

Integrated production (IP) of field bean should be carried out using integrated pest management and using technical and biological progress in cultivation and fertilisation with particular regard to human and animal health and environmental protection.

Integrated pest management includes all available actions and methods of protection against pests (weeds, pathogens, pests) with preference given to the use of non-chemical measures and methods that reduce the harmfulness of pests, in particular:

- the use of crop rotation, the appropriate date for sowing and plant density;
- the use of appropriate agrotechnology, including the use of mechanical plant protection;
- the adoption of appropriate measures and methods for the protection of plants against pests should be preceded by the monitoring of their presence and take into account current knowledge on the protection of plants against pests;
- the use of seed of at least the certified category, which has been produced and evaluated in accordance with the seed regulations;
- the use of resistant and tolerant varieties (where possible);
- the application of fertilisation and liming, where appropriate;
- the use of hygiene measures (cleaning, disinfection) to prevent the occurrence and spread of pests;
- the protection of beneficial organisms and creating favourable conditions for their occurrence, in particular for pollinators and natural enemies of harmful organisms.

In the framework of integrated plant protection, when carrying out a chemical plant protection treatment, account should be taken of:

- the appropriate selection of plant protection products in such a way as to minimise the negative impact of plant protection treatments on non-target organisms, in particular pollinators and natural enemies of harmful organisms;
- limiting the number of treatments and the quantity of plant protection products used to a necessary minimum;
- preventing the formation of resistance of harmful organisms to plant protection products by appropriate selection and their alternating use;

Plant protection products authorised for use in European Union countries are subject to periodic review in accordance with the latest studies and principles set out by the European Union. Strict requirements in terms of their quality, toxicology and effects on arable crops and the environment are monitored so that they do not pose a risk to the user, the consumer and the environment.

Plant protection products should be used in accordance with the current field bean protection programme with the recommendations given on the label and in such a way as to avoid endangering human or animal health or the environment.

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/ochrona-roslin.

The list of plant protection products authorised for IP is available in the Pest Warning System at: https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.html.

For protection against pests (weeds, diseases, pests), only products registered and authorised for marketing and use in Poland may be used which are clearly indicated on the labels attached to the packaging that they are recommended for use in field bean cultivation.

It should be borne in mind that the products included in the protection programme do not present a risk when properly applied in accordance with the approved labelling of the plant protection product. Adherence to application recommendations, such as the appropriate selection of the product, dose, the date of use, the appropriate stages of development of the crop and pests, the appropriate thermal and humidity conditions and the technical conditions for the procedure have a decisive impact on the safety of treatments with plant protection products.

In order to perform laboratory diagnostics (usually in the case of determining the pathogens), tests are carried out in laboratories accredited to the appropriate extent in accordance with the provisions of the Act of 30 August 2002 on the Conformity Assessment System or the provisions of Regulation No 765/2008.

7.1. WEED INFESTATION CONTROL

Field bean stands out among the coarse-seeded Fabaceae for its greatest competitiveness against weeds. However, in the initial period of development, a long germination period and low plant density promote weed growth. The greatest threat to field bean is weed infestation occurring in the initial period of growth: from sowing to developmental stage BBCH 3 (shoot elongation), in the so-called ‘period of critical weed competition’. During this time, it is necessary to provide plants with a weed-free field. Their occurrence at a later stage is not as dangerous, but it may adversely affect the quantity or quality of the crop, depending on the species composition and the abundance of weeds.

Weed protection as part of integrated pest management aims to reduce weeds, but not to eliminate them altogether (Dobrzański and Adamczewski 2009; Adamczewski and Dobrzański 2012; Woźnica 2012).

7.1.1. The most important weed species

In field bean, the most common species are annual weeds with lower thermal requirements during germination. These are usually species such as: white goosefoot, geranium, field madder, field pansy, common chickweed, speedwells, and knotweed and chamomile weeds, and among perennial species: couch grass, thistle, and dandelions. Weeds that thrive in shading (e.g. couch grass, knotweeds, and chamomile weeds) are a particularly high risk. The extent of harmfulness of the species most commonly found on field bean plantations is shown in Table 4.

Table. 4. The most economically important weed species in field bean cultivation (Strażyński et al. 2016)

Species	**Significance**
Geranium (*Geranium* spp.)	+ +
Common mugwort (*Artemisia vulgaris*)	+ +
Cornflower (*Centaurea cyanus*)	+ +
Barnyard grass (*Echinochloa crus-galli*)	+ +
Common fumitory (*Fumaria officinalis*)	+
Small bugloss (*Anchusa arvensis*)	+ +
Violets (*Viola* spp.)	+
Chickweed (*Stellaria media*)	++
Pinweed (*Erodium cicutarium*)	+
Dead-nettles (*Lamium* spp.)	+
White goosefoot (*Chenopodium album*)	+ + +
Field poppy (*Papaver rhoeas*)	+
Tripleurospermum inodorum O*Matricaria maritima* L. subsp. *inodora*)	+ +
Dandelions (*Sonchus spp.*)	+ +
Creeping thistle (*Cirsium arvense*)	+ + +
Couch grass (*Elymus repens*)	+ + +
Field bindweed – *Convolvulus arvensis*	+
Speedwell (*Veronica* spp.)	+
Cleavers (*Galium aparine*)	+
Common knotgrass (*Polygonum aviculare*)	+
Pale persicaria (*Polygonum lapathifolium*)	+ +
Black-bindweed (*Fallopia convolvulus*)	+ + +
Field chamomile (*Anthemis arvensis*)	+ + +
Chamomile (*Chamomilla recutita*)	+
Rapeseed (*Brassica napus*)	+ +
Field horsetail (*Equisetum arvense*)	+
Shepherd's purse (*Capsella bursa-pastoris*)	+
Field pennycress (*Thlaspi arvense*)	+

+ low or local harmfulness, ++ high harmfulness, +++ very high harmfulness

7.1.2. Agrotechnological methods of weed management

Weeds are an inseparable part of farmland. The primary source of weeds is their diasporas (seeds, rhizomes, runners, tubers, bulbs) occurring in the top layer of the soil. They are usually called ‘soil seed bank’, which constitutes the so-called ‘potential weed infestation’ (of soil). On the other hand, weed seedlings occurring in a crop are defined as: ‘current weed infestation’.

Uncontrolled weed development usually results in the occurrence of undesirable vegetation in an amount or mass significantly limiting yield.

In integrated production, various methods of weed control should be implemented, taking into account preventive measures and direct methods of weed destruction. The main cause of weed infestation is the 'soil seed bank', which is why efforts should be made to reduce its abundance through various treatments, in all possible phases.

The strategy to reduce the size of the 'soil seed bank' of weeds should be initiated during the post-harvest tillage operations. These treatments should in particular target species of perennial weeds reproduced by underground stolons or rhizomes, such as: dandelions, thistles, field bindweed, sorrel. Subsequent cultivation treatments that stimulate weed diaspores to germinate, and then combat their seedlings, significantly reduce the number of active seeds in the top layer of the soil.

An important factor limiting weed growth is the uniform emergence of the crop at optimal planting density. Therefore, it is necessary to sow healthy, good-quality seed at the recommended agrotechnical dates and sowing density. Optimal planting reduces the risk of secondary weed growth.

In integrated production, treatments should be applied to limit both potential and current weed infestation. The most important activities include:

- appropriate selection of the site, taking into account crop rotation;
- weed control in the post-harvest cultivation of precursor crops based on mechanical or chemical treatments;
- the use of crop treatments as appropriate and in a way that does not lead to soil pulverisation and drying;
- the use of seed of at least the certified category; adequate quality of seed ensures a fast, even emergence and planned plant density, provided that sowing is carried out under optimal conditions (sowing date, sowing depth, soil temperature and moisture, etc.).
- application of sustainable fertilisation;
- application of hygiene measures consisting of regular cleaning of machinery and equipment to prevent the spread of weeds;

Prevention and agrotechnical methods

These include: selection of a suitable site for cultivation, appropriate crop rotation to prevent weed compensation, selection of varieties adapted to local soil and climatic conditions, careful soil cultivation, fertilisation based on analyses of the fertilisation needs of the crop and soil nutrient levels to achieve full crop vigour, appropriate sowing dates and plant density, careful maintenance during cultivation, and, as far as possible, preventing weeds from producing seeds.

Mechanical methods of weed control

Before the emergence of field bean (BBCH 01-08), weeds should be controlled using a light harrow, applying one or two harrowings of the plantation. In these treatments, in addition to combating weed seedlings, it is beneficial to break up the top layer of the soil. It is important that the working elements of the weeding tools, which shallowly loosen the soil surface, do not come into contact with the delicate germinal shoot (epicotyl) of the field bean plants.

During the field bean emergence period (BBCH 09-11), when a delicate epicotyl breaks through the soil surface, mechanical treatments cannot be performed due to the high sensitivity to mechanical damage.

After emergence, mechanical weeding with a harrow should be carried out from the 2-3 leaf stage of field bean (BBCH 12-13). In the optimal determination of the post-emergence weeding date, it is crucial to obtain evenly aligned emergences of field bean plants. Therefore, it is important to precisely sow to an even depth in well-cultivated soil. Emergence harrowing should be carried out on a sunny day, when the top layer of the soil is dry and the plants are in conditions of reduced turgor (hydration of plant tissues). For these treatments, afternoon hours are a more favourable time of the day. Weeds are most effectively destroyed in the earliest stages of growth - during the germination and seedling phases.

The intensity of weeding of the harrow depends on the type of harrow, the angle of inclination of its working teeth, the speed of work, and the compactness of the soil. Emergence weeding with a weeder requires sowing at a greater distance between the rows (25-40 cm). Usually, 1-2 weeding treatments are applied, with the last treatment occurring before the inter-row closure.

7.1.3. Chemical methods of weed infestation control

The condition for effective action of herbicides is the correct diagnosis of weeds, selection of a suitable remedy and timely execution of the treatment. It should be remembered that in the case of prolonged drought, the action of herbicides applied in the soil (directly after sowing the field bean) is limited, and in this situation, it may be necessary to perform a corrective treatment with a foliar herbicide.

In integrated production, it is required to only use chemical herbicides listed in the: ‘List of herbicides recommended for the integrated production of agricultural plants’. The list of authorised plant protection products for certified integrated production is available in the Pest Warning System at the following address: https://www.agrofagi.com.pl/133,wykaz-srodkow-ochrony-roslin-do-integrowanej-produkcji-w-uprawach-rolniczych.

Plant protection products listed in the ‘List of Herbicides Recommended for Integrated Production (IP) of Agricultural Plants’ have been selected from the ‘Register of Plant Protection Products’ (https://www.gov.pl/web/rolnictwo/rejestr-rodkow-ochrony-roslin) on the basis of their harmfulness to humans and warm-blooded animals, in accordance with labels, permits, and decisions of the Ministry of Agriculture and Rural Development and the European Commission.

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/ochrona-roslin and https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie.

Crop rotation after herbicide use

Herbicides vary in duration of action and biodegradation in soil, which should be taken into account when planning subsequent crops. In each herbicide label, there is a section: 'CROP SUCCESSION', which provides information on the possible cultivation of successive crops. Most herbicides do not pose a risk to follow-on crops, but some herbicides persist longer in the soil and may cause symptoms of phytotoxicity or stunting on succeeding crops.

Weed resistance to herbicides and methods of limiting it

The occurrence of herbicide-resistant weed biotypes is a growing problem, which is why proper monitoring is crucial in terms of preventing weed resistance to herbicides.

A factor contributing to the development of weed resistance to herbicides is, inter alia, improper weed control based only on a widespread use of herbicides, without taking into account other methods, in particular agrotechnical ones.

The risk of weed resistance to herbicides increases when herbicides with the same mechanism of action are used cyclically. In order to counteract the risk of weed resistance to herbicides, it is necessary, among other things, to use herbicides alternately with a different mechanism of action or at least from different chemical groups. For this purpose, classification according to the mechanism of action of the active substance based on the HRAC classification (*Herbicide Resistance Action Committee*) should be used when selecting the herbicide for the procedure. The individual mechanisms of action of the active substances of herbicides according to this classification are currently assigned numerical codes (formerly, letter codes were commonly used, which can still be found in the labels of plant protection products).

7.2. REDUCTION OF PATHOGENS

7.2.1. The most important diseases

In order to achieve a high yield potential of this plant, at least several agrotechnical factors have to be taken into account, e.g. rotation, site selection, soil cultivation, fertilisation, sowing care. All this is aimed at creating optimal conditions for the growth and development of plants. Otherwise, the cultivated field bean may have increased susceptibility to pests, including pathogens. The infestation of plants by the pathogen causing the disease results in losses in the crop. The amount of losses in seed yield in field bean cultivation due to the occurrence of diseases is estimated at an average of 15 %, although sometimes they are significantly higher. The degree and severity of infestation of Fabaceae, including field bean, by pathogens depends on many factors, including weather conditions and agrotechnical procedures (Kurowski et al. 2006; Korbas et al. 2016).

Field bean is a species that can be infested by many pathogens. Diseases on the plant can be caused by one or more pathogens at the same time. The most important field bean diseases of economic significance include: ascochyta blight of field bean, chocolate spot of field bean, and rust of field bean, which is more dangerous for later ripening varieties (Jarecki and Bobrecka-Jamro 2014). In addition to the aforementioned diseases, the cultivation of field bean may be affected by: downy mildew of field bean, rhizoctonia of field bean, grey mould, wilt and dry root mould of field bean, sclerotinia rot, seedling blight and root mould, as well as clover rot on field bean. Table 5 presents diseases occurring in field bean cultivation and their economic significance.

Table 5. Economic significance of selected field bean pathogens in Poland

Disease	Pathogen(s)	Significance
Ascochyta blight of field bean	*Ascochyta fabae*	+++
Chocolate spot of field bean	*Botrytis fabae*	+++
Downy mildew of field bean	*Peronospora viciae*	+
Clover rot on field bean	*Sclerotinia trifolium var. fabae*	+
Rust of field bean	*Uromyces fabae*	+/++
Rhizoctonia of field bean	*Thanatephorus cucumeris Rhizoctonia solani*	+
Grey mould	*Botrytis cinerea*	+/++
Wilt and dry mould of field bean roots	*Fusarium oxysporum* f. sp. *fabae*, *F. solani*, *F. avenaceum*, *Rhizoctonia solani*	++
White mould	*Sclerotinia sclerotiorum*	+
Seedling blight, root mould	*Pythium debaryanum*, *Fusarium oxysporum*, *F. avenaceum*	++

\+ small +/++ low to medium ++ medium +++ large

Knowledge of the sources of infection and the conditions that are conducive to the occurrence of diseases is helpful in precisely determining the date of the procedure. Table 6 presents information that will facilitate the diagnosis of field bean diseases present during the disease vegetation period. This information should be used to precisely determine the date of eradication if a chemical method is needed.

Table 6. The most important sources of disease infection and favourable conditions for the development of their pathogens

Disease	Sources of infection	Favourable conditions for development	
		temperature	soil and air humidity
Ascochyta blight of field bean	wintering mycelium in seeds and plant residues, conidial spores spreading through wind and rain	18–20°C	excess rainfall and moisture in the soil
Chocolate spot of field bean	seeds, debris of infested plants, resting spores in soil, conidial	approx. 20°C	wet, rainy weather, high soil moisture,

	spores spread by wind and rain		lack of phosphorus and potassium
Downy mildew of field bean	spores on infected plants, seeds	approx. 15˚C	moist soil, high air humidity, dew
Clover rot on field bean	sclerotia (fungal resting bodies) in soil, crop residues	approx. 20˚C	rainy weather during the growing season
Rust of field bean	spores (urediniospores) in the air, remnants of infested plants	heat	wet weather
Rhizoctonia of field bean	spores in soil	heat	dry
Grey mould	crop residues, self-sown plants, weeds, seeds, soil	10–18°C optimum 15°C	high
Wilt and dry mould of field bean roots	remnants of infested plants, soil, seeds, spores carried by the wind	wide temperature range	excess and deficiency of soil moisture
White mould	sclerotia in soil and seeds	5–25°C, optimally 16–22°C	high
Seedling blight, root mould	soil, seeds	moderate	high

According to Kryczyński and Weber (2011); Korbas et al. (2015)

In order to effectively prevent the occurrence of diseases, it is important to correctly determine them. Table 7 describes the characteristic symptoms of the most important diseases occurring in field bean cultivation, the potential dates of their occurrence, and the organs of the plant to be observed. Pathogenic fungi can appear on all parts of the field bean and occur from the germination phase, when the radicle emerges from the seeds (BBCH 05) until the end of pod formation (BBCH 79) and even until the seed ripening phase (BBCH 85) – 50 % of mature dark pods (tab. 8). Detailed information on the potential dates of occurrence of bean diseases and how to monitor them can also be found in the online ‘Guidebook for Diagnosing Diseases of Coarse-Seeded Fabaceae Plants’ (Tratwal et al. 2017).

Table 7. Potential dates of occurrence and diagnostic features of field bean diseases

Disease	**Period of occurrence**	**Monitored organs and symptoms of infestation**	**Possibility of confusing symptoms**
Ascochyta blight of field bean	IV - VII	Symptoms of infestation occur on all overground parts of plants. On the leaves, the fungus produces oval brown spots with a lighter middle part and a dark reddish-brown border consisting of one or more rings. In the middle of the spots there are numerous black-brown fruiting bodies – pycnidia. On the stems, the spots are elongated and merge; where the spots occur, the stems are weakened and can break. On the pods, there are dark spots of irregular shape, more recessed. The spots often merge together and	chocolate spot of field bean

		form large necroses covering 70-80 % of the pod surface.	
Chocolate spot of field bean	VI - VIII	Symptoms of the disease most often appear on the upper surface of the leaves as small, clearly defined chocolate-colored spots with a slightly raised reddish-brown edge, measuring 0.5-3 mm in diameter. The center of the spots is often dried. Severely infested leaves dry up and fall prematurely. Brown-chocolate or brown necrosis may occur on the stems. Strongly infested stems break, and then the plants die. The stains on the infested pods are cherry-brown. With severe infestation, the young pods die and fall off. Particularly intense spread of the disease occurs in July and August.	ascochyta blight of field bean
Downy mildew of field bean	IV	Initially, chlorotic spots with a diameter of 1 to 3 mm appear on the leaf surface during the emergence of plants. On the lower part of the infested leaves, a loose coating consisting of spore-forming mycelium can be observed. With severe infestation, the leaves die off and the growth of plants is inhibited.	grey mould, early signs of rust of field bean
Rust of field bean	VI - VIII	The initial symptoms of the disease are visible in the form of yellowish spots, and later on, yellow-orange, dusty spore clusters are visible, arranged in a circular pattern. After 2-3 weeks, dusty, rusty-brown concentrations of summer spores appear first on the lower side of the leaves and then on the upper side of the leaves. Clusters are arranged randomly or in a ring shape. Strongly infested plants gradually turn yellow and die prematurely.	initial symptoms of chocolate spot of field bean
Rhizoctonia of field bean	IV - V	Necrotic spots of brown-black colour appear on the ground part of the stem and on the roots. On the stem at the level of the neck, there may also be a white mycelium of the pathogen causing the disease.	wilt and dry mould of field bean roots
Grey mould	V - VIII	Irregular, bluish-green spots on leaves, stems, and pods often with gray-brown mycelium and conidial stems and spores. Infected parts of the plant die off.	downy mildew, sclerotinia rot, ascochyta blight of field bean
Wilt and dry mould of field bean roots	V - VIII	The occurrence of the disease is observed in the form of blackening of the roots, drying of the edges of the leaves, and inhibition of seedling growth. On older plants, symptoms are visible on the stems and on the roots. Initially, dark brown discolorations appear in the form of elongated necroses. Infested plants are dying. With weaker infestation, the leaves turn brown and dry without setting seeds. Infested parts of plants during wet weather may have white mycelium or salmon-coloured spore clusters.	clover rot on field bean, rhizoctoniosis of field bean

White mould	V - VIII	Since flowering, white-gray spots appear on the stems, sometimes with zoning. Inside the stems or sometimes on their surface, there is a white cottony mycelium and black sclerotia of the fungus.	grey mould, wilt and dry mould of field bean roots
Seedling blight, root mould	III - IV	Some of the sprouts turn brown and die before emerging. After the risings on the ground part of the hypocotyl and on the roots, brown spots are formed. After some time, in these places the seedlings clearly narrow, and the plants wither and fall over. Strongly infested seedlings die off, while those that are less infested continue to grow, but their further development is significantly weaker. When there are high temperatures and water deficits at the base of the stem, there is a rapid development of dark necroses and breaking of the stems at ground level. The roots of diseased plants become brown and destroyed, as a result of which they can be easily pulled out of the soil.	damage by pests or use of the wrong herbicide, wilt and dry root mould in the initial stage of development

Table 8. Occurrence of symptoms of diseases on individual organs of the field bean

Disease	Root	Stem	Leaf	Inflorescence	Pod	Seeds
Ascochyta blight of field bean		x	x		x	x
Chocolate spot of field bean		x	x		x	x
Downy mildew of field bean			x			
Clover rot on field bean	x					
Rust of field bean			x			
Rhizoctonia of field bean	x	x				
Grey mould		x	x		x	
Wilt and dry mould of field bean roots		x	x			
White mould		x				
Seedling blight, root mould	x	x				

7.2.2. Agrotechnical methods of reducing pathogens

The agrotechnical method is based on the correct and timely execution of all actions related to planning and operation of sunflower cultivation.

Agrotechnical activities play a significant role in combating or preventing diseases. They reduce diseases occurring especially in the early stages of field bean development. The following elements of agrotechnics are important:

- appropriate rotation and site selection,
- proper preparation of the soil for sowing by autumn ploughing of crop residues,
- compliance with the rules of proper fertilisation, timing and density of sowing.

Field bean should not be grown after field bean and after other Fabaceae more often than every 4 years, because a significant increase in crop rotation diseases can be expected, including diseases caused by fungi of the species *Fusarium* causing wilt and root seedling blight. An important issue related to early sowing and often weak emergence is the phenomenon of so-called cold-water stress, which leads to physiological changes in the seed and seedling. They manifest themselves in the form of multiple shoots, damage to sprouts, and then the infestation of seeds and seedlings by fungi and the death of seedlings. The above symptoms are conducive to the sowing of excessively dried seeds (below 10 % moisture) during a cold and humid spring. Delaying sowing results in a decline in seed yield, prolongs growing, and increases the susceptibility of plants to disease infestation. Table 9 lists the most important non-chemical methods for reducing field bean diseases.

Table 9. The most important non-chemical methods of reducing field bean diseases

Disease	Reduction methods	
	agrotechnical	**cultivation**
Ascochyta blight of field bean	use of seed of at least the certified category, accurate harvesting and soil cultivation, fallow period	sowing of varieties with increased resistance
Chocolate spot of field bean	use of seed of at least the certified category, careful harvesting of plants and destruction of crop residues	as above
Downy mildew of field bean	use of seed of at least certified category, destruction of crop residues	–
Clover rot on field bean	interruption of cultivation	–
Rust of field bean	careful harvesting of plants and soil cultivation enabling the destruction of crop residues, correct rotation, lower sowing density, nitrogen availability	sowing of varieties with increased resistance
Rhizoctonia of field bean	ploughing of crop residues, destruction of volunteer plants	–

Grey mould	crop rotation, destruction of crop residues, spatial isolation of spring forms from winter forms, optimal fertilisation	–
Wilt and dry mould of field bean roots	use of seed of at least certified category, destruction of crop residues, correct rotation	–
White mould	crop rotation, varieties with higher resistance, proper sowing standard, optimal fertilisation	–
Seedling blight, root mould (various species of fungi)	crop rotation, optimal date of sowing; the correct depth and standard of sowing; good soil structure, balanced fertilisation	–

7.2.3. Chemical methods of reducing pathogens

The possibility of chemical protection for field bean is limited; therefore, only certified seed should be used, characterized by good plant health and, as far as possible, treated with products that limit seedling blight and other seed-borne diseases. Ensuring optimal conditions for emergence and development, especially in the initial stage of growth, makes plants less susceptible to infestation by pathogenic fungi.

Plant protection products should be used in accordance with the current list of products recommended for growing field bean in integrated production (IP). Information provided in the Pest Warning System (www.agrofagi.com.pl) may be helpful. Use instructions on the label should be read before application.

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/ochrona-roslin.

The list of plant protection products authorised for IP is available in the Pest Warning System at: https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.html.

7.3. REDUCING LOSSES CAUSED BY PESTS

7.3.1. Most important pests

The development of integrated rules for the protection of the field bean against pests, taking into account environmental aspects, is particularly important due to the large number of species damaging this group of plants. The extent of their harmfulness depends primarily on the weather conditions, the developmental stage and condition of the plant, as well as the method of cultivation. The greatest losses due to pest feeding can occur on seed plantations, with heavy infestation and plant damage leading to the liquidation of plantations or disqualification of seed material.

The growing threat from pests is mainly caused by the gradual increase in the area of cultivation of Fabaceae (Fabaceae). Simplifications of cultivation as a manifestation of production intensification, improper crop rotation, or insufficient spatial isolation also have a negative impact. Sometimes the problem is also incorrect monitoring of the most important pest species, their identification, determination of harmfulness thresholds, and timing for optimal control. The most important pests of field bean include: weevils, aphids, thrips, root flies, butterfly caterpillars, and soil pests (Hołubowicz-Kliza et al. 2018; Mrówczyński et al. 2017; Strażyński and Mrówczyński 2014, 2016, 2019; Tratwal et al. 2017) (tab. 10 and 11).

Table. 10. Economic importance of field bean pests

Pest	Current	Forecast
Aphids	+++	+++
Weevils	+++	+++
Broadbean weevil	+++	+++
Thrips	++	++
Root flies	+++	+++
Caterpillars	++	++
Lygus pratensis	++	++
Nematodes	+	+
Soil pests	++	+++
Snails and slugs	+	++

+++ very important pest, ++ important pest, + locally important pest

Table 11. Characteristics of damage caused by field bean pests

Pests	Characteristics of damage
Leaf weevil (*Sitona lineatus*) Lesser leaf weevil (*Sitona crinitus*) and others	Beetles feed on leaf blades by gnawing characteristic notches on their edges (so-called notched feeding damage). The greatest losses occur in spring (up to the 6-leaf stage), especially when warm and dry weather favours the development of insects on young seedlings. In later phases, more serious damage occurs as a result of the reduction of the assimilation surface of plants and the risk of secondary infestations by pathogens. Larvae feed in the root zone on root

	nodules, limiting the fixation of atmospheric nitrogen.
Beet leaf aphid *(Aphis fabae)* Pea aphid (*Acyrthosiphon pisum*) Lucerne-grove aphid (*Aphis craccivora*)	Adults and larval stages of aphids are harmful. Aphids inhabit younger, apical fragments of plants. As a result of feeding aphids, the growth of plants is inhibited. Inhabited plant fragments may become deformed, wither, and dry out. Spores or other factors causing secondary fungal and bacterial infections may enter the feeding sites of aphids through damaged tissues. Aphids can transmit viruses as so-called vectors.
Bean thrips (*Kakothrips robustus*)	In the case of a high intensity of the pest, small, necrotic spots are visible on the damaged leaves (white on flowers, silvery on young pods); eventually these organs wither and fall, and the pods become stunted. The harm caused by thrips is greater, the younger the plants that are attacked.
Broadbean weevil (*Bruchus rufimanus*)	The larvae bore into the pods and then into the seeds. The bite mark on the pod heals over and becomes almost invisible (small, dark spot). The inhabited seeds have a lid on the surface cut by the larva with a diameter of about 2 mm. Depending on the stage inside the insect, they are lighter (pupa) or darker (beetle). In one bean seed, several larvae can develop. Inside bored seeds, pupation occurs. After wintering inside the grains in storage rooms (part of the population overwinters outside), adult beetles fly out in spring for the first foraging and copulation (beetles do not reproduce in warehouses).
Bean seed fly (*Delia florilega*) Root fly (*Delia platura*)	The larvae bore into the seeds or feed on sprouts and young cotyledons. Early infested plants do not germinate or develop well, and their cotyledons are irregularly bitten and blackened. Bean seed fly is common, sometimes in high intensity, especially on damper, freshly ploughed soils, or after fertilisation with manure.
White grub (Scarabaeide) Cutworm (Agrotinae) Wireworms (Elateridae)	Larvae damage the underground parts of plants. They can eat swelling seeds, seedling roots, or gnaw the stems of young plants at the base. Mass foraging of the larvae is manifested by patchy losses in sowing (the so-called bald spots) – mainly from the edges of plantations.
Leaf-damaging caterpillars (Lepidoptera)	Butterfly caterpillars feed on leaves and, in cases of mass occurrence, can lead to partial defoliation of plants.
Chafers (*Lygus* sp.)	Both adult and larval stages of the chafers are harmful. They suck the juices from the tissues of the leaves, causing their deformities and often secondary infestations by the pathogens.

7.3.2. Pest monitoring methods

Monitoring for the presence of pests in a plantation is a very important part of integrated plant protection. Continuous observation facilitates the assessment of the current situation in the field and, if necessary, allows for a quick response. Therefore, it is necessary to systematically monitor the occurrence of pests from the time of emergence to maturation, at least once a week, using appropriate methods. The basic element underpinning a properly set date for pest control is the monitoring of pest flights and number. Monitoring is carried out primarily on the basis of visual inspection or – in the case of soil pests – soil sieving. Other methods are also useful, such as sweep-netting or sticky boards. The basic method of plantation inspection is visual inspection (tour). Depending on the shape of the field, it should include the edge of the plantation and two diagonals. Depending on the pest species, the average number of pests per 1 m^2 or 100 randomly selected plants should be checked. Such observations should be carried out in several places on the plantation. A useful method is sweep-netting. This is an easy and quick way to make an initial assessment of the species composition and number of insects on a plantation. Correctly applied, this method of monitoring makes it possible in a relatively short time to obtain preliminary information not only about pests, but also about other insects, including beneficial ones located on the plantation. However, it should be remembered that this method is not precise and in the event of a detected threat, more detailed inspection of the plantation should be carried out. For the purpose of initial inspection, 25 strokes should be made with a sweep net from the edge of the plantation, moving inside it. Sweep-netting should always be carried out in the place most vulnerable to pest infestation, for example from last year's location of the crop concerned. Observations on the occurrence of soil pests involve sifting soil from several locations from dug holes measuring 25 × 25 cm and a depth of 30 cm. The essence of proper pest risk assessment is understanding the basics of the morphology and biology of a given pest species, such as the timing of potential occurrence on the crop. Monitoring should be carried out both in order to determine the time of infestation and number of harmful insects on the plantation, as well as after the procedure to check the effectiveness of the control. In case of unsatisfactory effectiveness, the occurrence of resistance or prolonged infestations of harmful insects, such treatment gives the possibility of a quick reaction and, if possible, a repeat treatment. Due to many factors determining the occurrence of pests, monitoring should be carried out on each plantation. Proper inspection requires knowledge of pest morphology biology. Regardless of the monitoring method used, the results of observations should be recorded (Tratwal et al.). 2017).

Constant monitoring is necessary to determine the optimal treatment timing due to the continuous operation of many environmental factors, and only direct observations enable assessment of the actual threat from pests. Threats can vary depending on climatic conditions, terrain, plant growth stage, natural enemies or even fertilisation level.

Integrated plant protection programmes require considerable knowledge and experience from the farmer, ranging from pest identification to elements of development and habitation to ways of pest reduction and elimination. Information on pest biology, data from previous years on the occurrence of a pest in a given area combined with knowledge of measures to reduce losses can help in deciding on a treatment. The benefits of knowledge of modern methods of plant protection are not only economic. The lack of chemical pest control also translates into a healthier environment.

One of the tools facilitating the implementation of the principles of integrated plant protection is systems supporting the adoption of decisions in plant protection. These systems are helpful in determining the optimal deadlines for performing plant protection treatments (in correlation with the plant growth phase, pest biology and weather conditions), and thus make it possible to achieve high efficiency of these treatments while limiting the use of chemical plant protection products to a necessary minimum.

The Online Pest Warning System operated by the Institute of Plant Protection – National Research Institute and partner institutions features, among others, the results of monitoring of individual stages of pest growth in selected locations for the needs of short-term forecasting. If the threshold of economic harmfulness is exceeded in individual cases, the system indicates the need to perform treatments. In addition, the system offers instructions that facilitate proper control of plantations and making decisions about the optimal treatment dates. For each pest species, basic information is provided on its morphology, biology and methods of field observation, as well as the value of the thresholds for economic harmfulness. Thresholds of economic harmfulness are the fundamental basis for rational protection. In the case of field bean, specific harmfulness thresholds are developed for certain pest species. The principles and deadlines for their observation and the harmfulness thresholds are set out in Table 12.

Table 12. Periods and conditions for observation and harmfulness thresholds for field bean pests

Pest	Principle and period of observation	Harmfulness threshold
Weevils	Inspection of crops for beetles and damage (notched feeding damage) – BBCH 10-19 (pair of scaly leaves – 9 true leaves)	From emergence to the 2-3 leaf stage – 10 % of plants with damaged leaves or 2 beetles per 1 m^2
Aphids	presence of aphid colonies on all vegetative organs – growth and flowering (BBCH 30–69)	Before flowering: single aphids on 20 % of plants. During the flowering period: the beginning of the emergence of colonies on 10 % of plants.
Caterpillar that damage the leaves	Inspection of crops for caterpillars, weaving, and faeces, and leaf damage – development from shoot growth to pod ripening (BBCH 21-75)	None specified
Soil pests	Inspection of crops for root, embryo, cotyledon damage (characteristic bare patches in sowing) – leaf emergence and development (BBCH 09-15)	None specified
Lygus pratensis	Inspection of crops for the presence of imago and larvae, and damage to leaves, flowers, and pods – development from shoot growth to pod ripening (BBCH 21-75)	None specified
Thrips	presence of imago and larvae on all vegetative organs – BBCH 11-89 (first leaf unfolded – fully ripened)	20 eggs or larvae on 10 flowers

Broadbean weevil	presence of beetles (mainly on inflorescences) – BBCH 60–70 (first flowers open – first pods of typical length)	During the pod-forming period: 2 beetles per 1 m^2 or 1-2 beetles per 50 plants
Root flies	Presence of diptera during the emergence period – BBCH 10-19 (pair of scaly leaves – 9 true leaves)	None specified

7.3.3. Agrotechnological methods for pest control

Preventive actions based primarily on agrotechnology are one of the basic assumptions behind integrated field bean protection against pests. Correct agrotechnology and replenishment of any mineral nutrients improves the condition of the plants, especially in the early growth stages when they are particularly vulnerable to attack from particular pest species. Properly conducted protection is intended to encompass a wide range of agrotechnical methods. The increasing use of tillage simplifications, combined with climate change, creates favourable conditions for pest development. Proper adherence to basic agronomic recommendations is a key element of the programme of sunflower protection from pests (Table 13).

Table 13. Agrotechnical methods for the reduction of field bean pests

Pest	Protection methods
Weevils	crop rotation, shallow tilling, as early sowing as possible, spatial isolation from other Fabaceae (including perennial), post-harvest tillage
Aphids	early sowing, balanced fertilisation (particularly N), spatial isolation from other Fabaceae (including perennial), containment of weeds infestation, post-harvest tillage
Lygus pratensis	spatial isolation from other Fabaceae (including perennial), containment of weed infestation, post-harvest tillage
Broadbean weevil	early sowing, spatial isolation from field bean crops, possibly early harvest, post-harvest tillage
Root flies	crop rotation, early sowing, increasing the sowing standard, reduction of weed infestation, post-harvest tillage
Thrips	crop rotation, spatial isolation from other Fabaceae
Soil pests	crop rotation, shallow tilling, discing, weed infestation control, spatial isolation from meadows, fallow land, root crops, post-harvest tillage
Caterpillars	crop rotation, spatial isolation from other Fabaceae (including perennials), weed control

For field bean, as in other Fabaceae, it is very important to use correct crop rotation. Many pests overwinter in the top layer of soil or leftover plant residues. Properly planned crop rotation should take into account cereal, root and fodder crops. In the case of monocultures, pests after wintering have facilitated access to the food base. For the same reason, it is recommended to use spatial isolation from other Fabaceae plants (also cultivated in the previous year) and other host plants of individual pests, e.g. perennial Fabaceae in the case of pea aphids or Lygus bugs. Spatial isolation also helps make certain pests fly over longer distances.

Preparation of the place for cultivation, possible addition of minerals and further balanced fertilisation improves the condition of the plants. This is particularly important in the early stages of plant growth when they are extremely sensitive to attack by individual pest species. Appropriate steps to limit the potential damage caused by pests can also be taken at the seeding stage. Faster initial vegetation of plants makes it possible to get ahead of the period of greatest danger from all pests, especially those that are dangerous for emergence. In addition, faster growth helps choke weeds that can be a food base for some pests. The plant density is also important. Too dense sowing makes it easier for pests to spread, while sowing too sparsely promotes weeding. In addition to competition for water, light and nutrients, weeds are also the food base for some pests, e.g. aphids. The date of harvesting is also very important – too late creates a risk of greater losses, especially qualitative, by insects that can damage the pods.

After harvesting, it is important to perform post-harvest cultivation treatments, aimed at precise fragmentation of crop residues (places of wintering and development of certain pests), controlling weed seeds, including perennial ones. Post-harvest tillage should be completed by deep autumn ploughing, which serves a phytosanitary role. A thick layer of soil covers the wintering stages of pests, weed seeds and fungal spores. It also brings to the surface pests that are found deeper, exposing them to adverse weather conditions. Simultaneously, soil pests are mechanically destroyed (Tratwal et al.). 2017).

7.3.4. Chemical methods of pest control

Plant protection products should be used in accordance with the current list of plant protection products recommended for field bean cultivation in integrated production. The messages provided in the Online Pest Warning System may be helpful (www.agrofagi.com.pl). Use instructions on the label should be read before application. The list of plant protection products authorised in Poland is published in the relevant register. 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/ochrona-roslin.

The list of plant protection products authorised for IP is available in the Pest Warning System at: https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.html.

8. BIOLOGICAL METHODS AND PROTECTION OF BENEFICIAL ENTOMOFAUNA IN INTEGRATED PRODUCTION OF FIELD BEAN

Biological methods consist of the use of natural biological agents such as: viruses, microorganisms (bacteria, fungi) and macroorganisms (nematodes, parasitic and predatory insects and mites) to reduce the population of pests, pathogens and weeds in plant crops in the field and under covers. Biological agents, like chemical agents, combat pest populations, but their mechanism of action varies.

In biological pest control, three main methods are distinguished:

1. Introduction, i.e. the permanent establishment in new areas of natural enemies imported from other regions or continents — the classical method;
2. The use of naturally occurring and specially introduced into agricultural and forest areas landscape elements enabling and enhancing the development of populations of beneficial organisms that naturally occur in these environments — the conservation method;
3. Periodic colonisation, i.e. the periodic introduction of natural enemies of a given pest, on crops that do not occur or occur in small quantities — the augmentative method.

In field crops, the use of biopreparations containing parasitic microorganisms is uncommon. First of all, the interest of producers in these measures is low, as they require more knowledge and precision in their application. Registered micro-organisms are effective provided that they are used in accordance with the product label. Their effectiveness is influenced by weather conditions in the field, which often change. These include: temperature, humidity and insolation. However, it must be remembered that when introduced into the environment these factors persist for a long period.

Reducing the population of pests in field bean with the use of bioinsecticides

In the cultivation of field bean, the most dangerous pests are: broadbean weevils, leaf weevils, thrips, bean seed flies, aphids, cutworms, white grubs, and wireworms. Microbial bioinsecticides containing the bacteria *Bacillus thuringiensis* or the insecticidal fungi *Beauveria bassiana* are available to control leaf-damaging caterpillars, whiteflies, thrips, wireworms, and hop spider mites. Currently registered bioinsecticides can be found using the search engine for plant protection products available on the website of the Ministry of Agriculture and Rural Development: https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie.

When using microorganisms to control field bean pests, it should be remembered that:

- they are sensitive to high temperatures and strong sunlight,

the bacteria are best used when the first caterpillars/larvae of the pest appear, as the younger stages of the pest are more sensitive to insecticidal bacteria;

- insecticidal fungi, at the first stage of action, require a temperature of approximately 25°C and high humidity to germinate and penetrate the insect,
- the pest's caterpillars die 24–72 hours after consuming fungal spores. During this time, they can feed and look healthy,

micro-organisms are applied using self-propelled or tractor-mounted sprayers. Such procedures should be performed in the evening or early in the morning,

- chemical fungicides must not be used after the application of biological agents containing micro-organisms (this is particularly relevant for products containing fungi in the composition of the product),

they are living organisms and have a short shelf life at room temperature, but can be stored in the refrigerator for up to 6 months.

- it is required to carefully read the labels of biological products before using them to avoid potential errors in their application,
- it is required to pay attention to the information on the pH of the working liquid and its mixability with chemical products (usually this information can be found on the labels; in case of doubt, contact the representative of the company placing the product on the market),
- when using biological products based on living organisms, it is very important to monitor crops in order to select the appropriate date for the application of the solution.

1. Mechanism of action of parasitic fungi and conditions of use

The infectious stage of the insecticidal fungus, which is the active substance of the bioinsecticide, consists of spores or hyphae of the fungus, which do not have to be ingested by the pest; it is sufficient for them to reach the surface of the host's body. They sprout and penetrate its interior. The insect dies from paralysis caused by the overgrowth of its body by the developing fungal hyphae. All stages of pest development are vulnerable. The time from infection to the death of the pest is from 3 to 7 days.

Insecticidal fungi, such as *Beauveria bassiana*, are sensitive to low and very high temperatures. The optimal temperature for spore germination is 25^{0}C. High humidity is required for the penetration of spores into the body of the pest. Micro-organisms are applied using self-propelled or tractor-mounted sprayers. The use of an insecticidal fungus in the form of a registered biopreparation means that the biological agent introduced into the environment can also act on other pests not listed on the label of the product for a long period of time. Fungus *B. bassiana* is a known biological agent commonly found in soil and may, for example, reduce the different stages of development of pests wintering in soil.

Symptoms of infestation by insecticidal fungi: the body of an infested insect often changes color. One of the typical symptoms is mummification; the body is hard, and on its surface in humid conditions, a mycelium of different colours is formed, depending on the species of fungus.

The biological preparation containing parasitic fungi should be stored in cool conditions at 2°-6°C.

2. Mechanism of action of insecticidal bacteria

The death of an insect occurs after consuming spores and toxic crystals (Cry protein) of bacteria, resulting from damage to the epithelial cells of its intestine, caused by endotoxin activity. The digestive tract is paralysed and the insect stops feeding. The most sensitive are the younger larval stages of insects.

The body of the infested insect darkens and becomes almost black due to necrotic changes.

It is important to remember that:

In the environment, biological factors, i.e. elements of the living environment, directly or indirectly affect the life of organisms. An example is the antagonistic action of bacteria of the genus *Bacillus* and *Pseudomonas* on the insecticidal fungus *B. bassiana*. These species should not be combined with each other. Similar interactions can occur in the environment between species; therefore, familiarising oneself with the product label is the first step to avoid potential errors.

With field bean cultivation, snails can prove problematic. They can be controlled with available biological preparations having macroorganisms – nematodes – as their active ingredient. Macroorganisms are not subject to registration in Poland. Larvae of the insecticide nematode – *Phasmarhabditis hermaphrodita* penetrate the snails' body through the respiratory canal, infecting it with bacteria and making it stop foraging after 3-5 days. The application of the agent to a moist substrate increases its effectiveness. The preparation is retained in the soil for about 6 weeks. When using nematode preparations, it is necessary to know that the sprayer should have nozzles greater than 0.5 mm, and the pressure of 300 psi should not be exceeded. The preparation contains living organisms – larvae of nematodes, so their use must be carried out especially carefully and according to the label of the product.

Reducing pathogens in field bean cultivation

In field bean cultivation, a biofungicide containing the bacterium *Bacillus amyloliquefaciens* is used preventively to control the causative agent of sclerotinia rot. The bacterium that naturally occurs in the environment works by disrupting the germination of spores and inhibiting the development of the pathogen mycelium. Biofungicide can be stored at temperatures of 4°-25°C.

Conservation biological protection

Biological protection is not only about the use of registered microbiological biopreparations. It is also supported by nature and the use of **the conservation biological method**. It involves the modification of the agricultural landscape by humans in order to create appropriate conditions for the action of beneficial organisms occurring in the environment (Sosnowska 2018, 2022). The number of beneficial organisms can be increased, among others, by sowing melliferous plants in the vicinity of crops, flower strips or leaving natural furrows. Midfield woodlots and bushes play a big role. These sites serve as habitats for those organisms that significantly reduce populations of various pests. Hence the need to ensure an increase in the number of beneficial organisms near the crop through field scrub and flower strips. A very important element is the rational use of selective chemical plant protection products, allowing to reduce their negative effects on beneficial organisms. The decision on the need to perform chemical treatment in the field should be made on the basis of the real threat of pests to cultivation.

A large role in nature is played by beneficial macroorganisms, i.e. parasitic and predatory insects, mites, and insecticidal nematodes (they are not subject to registration in Poland). Under natural conditions, the importance of beneficial ground beetles is growing in integrated plant protection. They are abundant in all agricultural environments, including in field bean crops. They are found on the top layer of soil and litter. Due to their large size, high motility and great voraciousness, they are among the most effective beneficial insects, significantly reducing the number of plant pests; among others, they feed on eggs, pupae and larvae/caterpillars of many species of butterflies, beetles and Hymenoptera. The herbivorous corn ground beetle (*Zabrus tenebrioides*) is an exception in the family of ground beetles, considered to be a pest.

A small parasitic wasp can be found under natural conditions: *Trichogramma* spp., approximately 1 mm in size. It is, among others, a parasite of corn borer eggs. A Trichogramma female can lay up to 300 eggs, so the scale of pest egg parasitisation can be large. In Poland, biopreparations containing Trichogramma are available for use mainly against the corn borer. However, the Trichogramma parasitises in the eggs of many other species of pests.

Another problem in the field bean is aphids. In natural conditions, aphid populations are reduced by many species of predatory insects, such as ladybirds (Coccinellidae). One larva, throughout its development (approx. 30 days), can eliminate from 100 to 200 aphids. A beetle eats 30-250 aphids a day. Given that aphid flights usually occur earlier than those of ladybirds and other useful insects, it is necessary to decide whether chemical treatment with a plant protection product is needed. If necessary, it should be done as early as possible, before the flight of natural enemies, or restricted to the edge strips of the plantation, or even for a spot treatment by choosing a selective insecticide. Net-winged insects (Neuroptera) also eat aphids. Green lacewing larvae eat up to 400 aphids. However, despite enormous aphidicidal effectiveness, the high motor activity of these insects significantly hinders the ability to control their populations, both natural and artificially introduced into crops. Aphids are also preyed upon by species of soldier beetles (Cantharidae), gall midges

(Cecidomiidae), earwigs (Dermaptera), as well as predatory insects such as specialized aphid wasps (Aphidiidae) (Tomalak 2008).

Under favourable conditions (high humidity and temperatures above 20 °C), insecticide fungi belonging to insect destroyers (Entomophthoraceae) play a major role. These fungi can cause epizootic diseases, i.e. mass extinction of aphid colonies. The development of insecticide fungi is promoted by water habitats, strongly humidified habitats, forests, woodlots, rushes and meadows. Forests are more than twice as rich in insecticidal fungi as agroecosystems (Tkaczuk et al. 2016). Insecticides can reduce populations of wintering pests in soil conditions, such as cutworms and weevils. Insecticidal fungi species develop in the soil, such as: *Beauveria bassiana*, *Metarhizium anisopliae* and *Cordyceps fumosorosea*. The effectiveness of these fungi is best at high humidity and a temperature of 25°C. Insecticidal fungi also develop on the surface of the plant. Parasitized insects, such as aphids, can often be found on leaves. Insecticides and viruses can also play an important role.

In the environment, not only beneficial insects and microorganisms play a role in reducing pest populations. There are other animals, such as amphibians, birds or mammals (Wiech 1997). The grey toad plays a useful role in agrocenoses. This large amphibian feeds on a variety of foods, predominantly snails and insects, often harmful ones. One of the insectivorous mammals is the mole. It is a useful animal that feeds on white grubs and other insects found in the soil. The largest representative of insectivorous mammals is the hedgehog, which hunts at night, and its food is insects, snails, and other animals. Birds play a useful role in the environment. Therefore, in integrated field bean production, it is required to create appropriate conditions for the presence of birds of prey, which involves the setting up of resting poles. Birds destroy various pests.

Unfortunately, it is not possible to ensure the protection of the field bean with the exclusive use of biological agents. The field bean conservation strategy should include a complex of actions based on different methods, mainly non-chemical, and the aim of minimising the use of chemical plant protection products. Although we do not currently have a large assortment of biological plant protection products for field crops, the current strategies of the European Union, as well as the reduction of chemical plant protection products, will contribute to increasing the range of these products in the coming years.

Most of the biological agents available do not guarantee better effectiveness compared to chemical agents. This depends on many factors: biotic and abiotic. Farmers must be trained in the availability, mode of use, and the advantages and disadvantages of biological plant protection products. The use of these measures requires a high level of knowledge, because when incorrectly used, they often have no desired effect. The greatest advantage of biological agents is their safety for the environment. They enrich the biodiversity of the agricultural landscape, are safe for the consumer and beneficial organisms, do not require a withdrawal period, and once introduced into the environment, they may persist for a long time and under natural and optimal conditions for their development, they can reduce pest populations without reintroduction. Other benefits of using them include: the absence of residues, their non-toxicity to entomophages, their often environmental biodiversity. Biopreparations also have disadvantages, such as sensitivity to environmental conditions (temperature, humidity), high cost in production and application, short lifespan in the preparation, the need for precise execution of treatments, and a slow mechanism of action.

Plant protection products, including biological agents, should be used in crops where they are recommended for use and the information contained in the labelling of the product should be observed. The basis for their use is the monitoring of pest species.

Detailed information on registered plant protection products for field bean protection can be found at:

- Search engine for all plant protection products (including biological ones) registered in Poland https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie;
- Methodologies of Integrated Pest Management for Agricultural Crops on the Institute of Plant Protection — National Research Institute website https://www.agrofagi.com.pl/94,rosliny-rolnicze.

A list of plant protection products for integrated production in agricultural crops can be found at: https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.

Protection of bees and other pollinators

Legal protection of these organisms during chemical treatments is also an important element of modern plant protection. Integrated pest management includes 'the protection of beneficial organisms and the creation of conditions conducive to their occurrence, in particular pollinators and natural enemies of harmful organisms' (Pruszyński 2007, 2008).

Bearing in mind the obligation to carry out crop protection in accordance with the principles of integrated pest management, chemical plant protection treatments should take into account the selection of plant protection products in such a way as to minimise their negative impact on non-target organisms, in particular pollinators and natural enemies of harmful organisms.

A more efficient use of beneficial species can be achieved through a number of actions, including:

- rational use of chemical plant protection products and basing the decision on their use on the real risk to field bean cultivation from pests, assessed on an ongoing basis. One should consider abandoning treatments if pests do not appear in large numbers and are accompanied by the occurrence of beneficial species. Consideration should be given to limiting the treatment area to edges or patches if the pest is not present on the entire plantation. The use of tested mixtures of plant protection products and liquid fertilisers should be recommended, which reduces the number of entries into the field and reduces mechanical damage to plants;

- protection of beneficial species by avoiding the use of insecticides with a broad spectrum of activity and replacing them with selective agents;
- choosing the treatment time to prevent high mortality among beneficial insects;
- based on the results of studies, dose reduction and adjuvant addition;
- constant awareness that protecting natural enemies of field bean pests also protects other beneficial species present in the field;
- leaving balks, mid-field shelters as a habitat for many species of beneficial insects;
- reading carefully the content of the label accompanying each plant protection product and observing the information contained therein.

Other insects are also very efficient pollinators. In order to ensure the development of pollinators living in the wild in agrocenoses, and thus increase pollination efficiency, it is necessary to place mason bee houses or bumblebee mounds (scattered bags of peat) or other facilities for pollinators within the crop—at least 1 per 5 hectares.

9. PROPER SELECTION OF PLANT PROTECTION TECHNIQUES

Storage of plant protection products

Plant protection products should be stored:

a) in their original packaging, tightly sealed and clearly labelled and in such a way that they do not come into contact with food, drink or feed;

b) in a manner ensuring that they:

- are not consumed or intended for animal feeding,
- are inaccessible to children,
- there is no risk of:
  - contamination of surface water and groundwater within the meaning of the Water Law,
  - ground contamination due to leakage or seepage of plant protection products deep into the soil profile,
  - penetration into sewerage systems, excluding separate drain-free sewage systems equipped with a leak-proof sewage tank or equipment for their neutralisation.

The labels of plant protection products approved by the Minister for Agriculture and Rural Development contain information on the principles of safe storage.

Plant protection products in accordance with the principles of good practice should be stored in separate rooms (except residential and livestock buildings). These spaces should be clearly marked (e.g: ‘Plant Protection Products’) and secured against unauthorised access, i.e. locked.

If poisoning is suspected in connection with contact with a plant protection product, medical advice should be sought immediately and the doctor informed of the method of exposure to the specific chemical in question.

Requirements for professional users

Persons or sprayer operators handling plant protection products must be suitably qualified by a certificate of completion of training in the use of plant protection products or advisory on plant protection products and integrated plant production or another document attesting to acquired rights to carry out plant protection treatments.

The sprayer operator must be equipped with appropriate protective clothing, as prescribed by the label and the safety data sheet of the plant protection product. The basic equipment of protective clothing includes: a suit, suitable shoes, rubber gloves resistant to plant protection products, glasses and mask to protect the eyes, respiratory system and covering the mouth. Proper working organisation and available technical measures should be used at each stage of the treatment of plant protection products, in accordance with the principles of **Good Plant Protection Practice.**

Apparatus and equipment for protective treatments

The sprayer or other equipment used for crop protection must be technically efficient, ensure reliable operation and guarantee the safe use of plant protection products, liquid fertilisers or other agrochemicals. The sprayer must have an up-to-date condition test (certification) and shall be properly calibrated. The technical efficiency of the equipment is confirmed by the protocol of the test carried out and by the control mark issued by the units authorised to do so (sprayer inspection stations). Testing of new equipment shall be carried out no later than five years after its acquisition and subsequent tests shall be carried out at intervals of no more than three years.

Equipment used for plant protection treatments must be safe for people and the environment. In addition, it should guarantee the full effectiveness of the protective treatments by ensuring proper operation, allowing accurate dosing and even distribution of the plant protection products on the treated area of the field.

Before performing the procedure, it is necessary to check the technical condition of the sprayer, in particular the condition of: filters, pumps, lubrication and lubrication points, nozzles, field beam, measuring and control devices, liquid system and agitator. It is also advisable to carry out a preventive rinse of the sprayer to remove mechanical debris and any residues of previous treatments from the system.

Calibration (adjustment) of the sprayer

Periodic adjustment of the sprayer makes it possible to choose the optimal parameters of the treatment. In accordance with good plant protection practice in the adjustment (calibration) process of the sprayer, the type and dimension of the sprayers and the working pressure should be determined, which ensure the application of the assumed dose of liquid per hectare for the specified operating speed of the sprayer.

The adjustment of the sprayer's operating parameters should be performed when changing the type of chemical agent (especially from herbicide to fungicide or insecticide), the dose of the spray liquid, as well as the setting of operating parameters (working pressure, field beam height). The adjustment of the sprayer is carried out each time when replacing important equipment and components of the sprayer (sprayers, pressure gauge, control device, repair of essential elements of the liquid system), as well as when changing the tractor or tyres in the drive wheels. The discharge of the liquid from the nozzles at the specified operating pressure should be checked regularly. When adjusting the sprayer, attention should be paid to the flow capacity of the nozzles and the uniformity (type and size) of the nozzles mounted on the field beam.

An example procedure for calibration of the sprayer is contained in the Code of Good Practice for Plant Protection or other thematic studies in this area.

Choice of plant protection product and dosage

In line with the requirements of integrated pest management, selective measures with low risk to pollinators and beneficial organisms should be chosen.

Treatments with plant protection products should be planned to ensure acceptable efficacy with the minimum necessary amount of plant protection product applied, taking into account local conditions.

The dose of the plant protection product should be selected according to the producer's recommendation on the basis of the label, also taking into account the developmental stage of plants, their condition and climatic and soil conditions: wind, temperature and humidity of soil and air, type of soil as well as the content of organic matter in the soil.

The decision to use the plant protection product at a dose lower than that recommended on the label must be taken with great care, based on knowledge, experience, observations and professional advice. The use of reduced doses may lead to the development of resistance to active substances of plant protection products in target organisms.

When using plant protection products, also in split doses, it is necessary to comply with the requirements specified on the product label, i.e.

- **time intervals between treatments,**
- **the maximum number of times the product can be used during the season,**
- **the maximum dose of the plant protection product.**

Spray volume selection

In integrated crop protection systems, the volume of spray (l/ha) should be selected based on available catalogues, training materials and handbooks or other thematic studies. Factors such as the type of crop being sprayed, the development stage of the crop, the density of the crop, the possibility of using different spraying techniques (type of treatment apparatus, type and kind of spray equipment), as well as the recommendations contained on the label of the specific plant protection product, should be taken into account in the selection of spray volume.

Contact-action agents require very good coverage of the plants being sprayed and generally require higher volumes of spray than systemic agents. In foliar feeding treatments and when combining the use of several chemicals, it is recommended to use increased volumes of spray liquid. With appropriate treatment equipment (e.g. AAS sprayers), the liquid dose can be reduced to 50-100 l/ha, which should guarantee a sufficient quality of treatment coverage on plants.

Selection of sprayers

Spray nozzles have a direct impact on the quality of spraying and thus on the safety and effectiveness of plant protection products. Catalogues and general recommendations for their use in the protection of agricultural crops are useful in selecting the right nozzles for particular plant protection treatments.

The selection of the atomiser for specific protective treatments should be preceded by getting to know its technical characteristics, and above all information about the type, size of the spray slot, and intensity of the liquid discharge.

Preparation of the spray liquid

The planned volume of the spray liquid should be made up immediately before treatment to avoid undesirable physico-chemical reactions. The agitator of the sprayer must be speedwelled on at all times to prevent the mixture from precipitating at the bottom of the tank. Before pouring the product into the tank, it is necessary to read the indications on the label as to the method of preparation of the spray liquid and the possibility of mixing the product with other preparations, adjuvants or fertilisers.

The measurement of plant protection products and preparation of the spray liquid should be carried out in a way that reduces the risk of contamination of surface water, groundwater and soil and at a distance of no less than 20 m from wells, water intakes, reservoirs and watercourses.

<u>Sprayer filling</u>:

- the sprayer should be filled on impermeable and hardened ground (e.g. concrete slab) in a place that prevents spillage of spilled or spread plant protection products,
- the measured quantities of plant protection products should be poured into a tank

partially filled with water with the stirrer on or in accordance with the instructions for operation of the sprayer,

- plant protection product packaging must be rinsed three times, the contents poured into the spray tank, and the packaging preferably returned to the dealer;
- if possible, it is best to fill the sprayer on a special site with a biologically active substrate;
- when filling the sprayer on permeable ground, a thick plastic foil for collecting spilled or spread preparations should be laid down where the plant protection products are measured and introduced into the sprayer tank,
- spilled or scattered plant protection product and contaminated material must be safely managed using absorbent material (e.g. sawdust);
- contaminated absorbent material must be collected and submitted to a bioremediation site for plant protection products or placed in a sealed, labelled container,
- the container containing the contaminated material should be stored in plant protection product storage until safely managed.

Combined use of agrochemicals

In treatments with the use of several agrochemicals, the order of adding ingredients during the preparation of the spray liquid should be observed. A weighed portion of fertiliser (e.g. urea, magnesium sulphate) is poured into the sprayer tank half filled with water with the stirrer on. Further components are added to this solution. It is recommended that they be pre-diluted before pouring into the sprayer tank. Start with an adjuvant that improves compatibility of the components of the mixture, if used. Then plant protection products are added (in the correct order – according to the formulation) and supplemented with water to the desired volume of the sprayer tank.

In large-component mixtures with the use of two or more plant protection products, the order of their addition to the liquid should be followed – according to the physical characteristics of the formulations. First, add preparations that form a suspension in water, then add agents that form emulsions, and finally solutions. After adding all the components, replenish the tank with water to the required volume.

Do not use low temperature water (taken directly from a deep well) for the treatment. Very hard and contaminated water should not be used. Protective treatments may begin when the spray liquid is properly prepared.

Treatment conditions

Plant protection products should be used in such a way that they do not pose a risk to human health, animal health and the environment, including preventing the spread of plant protection products to areas and facilities not intended for treatment

Treatments with plant protection products should be carried out in light wind and rain-free weather and moderate temperature and sunshine. Spraying during adverse weather (stronger wind, high temperature and low air humidity) can cause damage to other plants as a result of the spray liquid drifting to areas not to be covered by the treatment, and may cause unintended poisoning of many beneficial species of entomofauna.

Table 14 shows recommendations for optimum and limiting weather conditions during spray applications. The recommended air temperatures during treatments are conditioned by the type and mechanism of action of the plant protection product applied and such data are included in the label texts. For most preparations, optimal effectiveness is achieved at a temperature of 12-20 °C.

Plant protection products can be applied in the open if the wind speed does not exceed 4 m/s. A slight wind, with a speed of 1 to 2 m/s, is also beneficial due to turbulence and better movement of the sprayed liquid among the sprayed plants. In weather conditions close to the upper (wind temperature and speed) or lower (air humidity) limit values, spray nozzles limiting drift (e.g. low drift or ejector) and lower recommended operating pressures should be used for spraying operations.

Table 14. Limit and optimal meteorological conditions for plant protection treatments

Parameter	**Limit values (extreme)**	**Optimum values (most favourable)**
Temperature	1-25 °C during treatment	12-20 °C during treatment
	up to 25 °C the day after treatment	20 °C on the day after treatment
	not less than 1 °C the following night	not less than 1 °C the following night
Air humidity	40–95 %	75–95 %
Rainfall	less than 0.1 mm during treatment	no rainfall
	less than 2.0 mm within 3-6 hours of treatment	
Wind speed	0.0-4.0 m/s	0.5-1.5 m/s

Plant protection products should be used in open areas by means of tractor sprayers and self-propelled field or fruit sprayers, if the place of application of these products is remote:

- at least 20 m from the apiaries,
- at least 3 m from the edge of the roadway with the exception of public roads classified in the category of municipal and district roads,

and

- in the case of tractor and self-propelled orchard sprayers, at least 3 m from reservoirs and watercourses and land not used for agriculture, other than for treatment with plant protection products,
- in the case of tractor and self-propelled field sprayers at a distance of at least 1 m from reservoirs and watercourses and land not used for agriculture, other than those treated with plant protection products.

It is important to bear in mind the obligation to comply first with the labelling of plant protection products. On many labels, distances (buffer zones) greater than those indicated above are provided from specific sites and facilities after which plant protection products should be used.

The spraying procedure is performed at a constant movement speed and working pressure, set during sprayer adjustment. Successive passes over the field should be made very precisely to avoid unsprayed strips and so that no overlapping of the sprayed liquid occurs in already sprayed areas.

Post-treatment procedure

At the end of each treatment cycle, removal of the spray liquid from the sprayer should be carried out by spraying the spray liquid in the field or plantation where the treatment was carried out or on the producer's own unused agricultural area, away from drinking water intakes, and sewer wells. The sprayer should be washed thoroughly, in the place intended for this purpose.

The remaining liquid must not be poured into the soil or into the sewage system or poured in any other place that prevents its collection or poses a risk of contamination of the soil and water.

Washing and rinsing the tank and the liquid sprayer installation should be carried out at a safe distance – no less than 30 m – from wells, water intakes and reservoirs and watercourses n.

Procedure for rinsing the tank and liquid system

- use the smallest amount of water necessary for flushing (2-10 % of the tank volume or an amount to dilute the remaining liquid in the tank up to 10 times) — it is recommended to flush the liquid system 3 times with a small portion of water;
- turn on the pump and rinse all the elements of the liquid system used during the procedure,
- spray the rinsings on previously sprayed surface or, if it is not possible to use the residue, according to the recommendations on the management of liquid residues.
- the residual liquid drained from the sprayer shall be disposed of using technical equipment that ensures biodegradation of the active substances contained in plant protection products. Until neutralisation or disposal, liquid residues may be stored in a sealed, labelled and secured container for that purpose.

External sprayer washing

After the end of the working day, wash all the apparatus from the outside with water, as well as components in contact with chemical agents.

external sprayer washing should be carried out in a place that allows rinsing into a closed collection system for contaminated residues or to a neutralisation/bioremediation system (e.g. biobed, Phytobac, Vertibac); if this is not possible, it is best to wash the sprayer in the field.

Wash the sprayer with a small amount of water, preferably using a high-pressure lance instead of a brush to shorten the time and increase the efficiency of external washing.

Use recommended, biodegradable means to increase washing efficiency.

Registration of treatments

Professional users of plant protection products are required to maintain and keep records of their plant protection products for three years. The documentation should contain information on:

- the names of the plant protection product,
- the date of application,
- the dose used,
- the area and crops on which the protective treatment has been carried out,
- reasons for the treatment with a plant protection product.

The law also requires the method of fulfilling the requirements of integrated pest management to be indicated in the documentation by providing at least the reason for the treatment with a plant protection product. **Filling the mandatory IP notepad in the system of integrated plant production fulfils the requirement to keep the above-mentioned documentation for certified crops.**

10. HYGIENE AND HEALTH PRINCIPLES

Personal hygiene of employees

Persons working in the harvesting and preparation of crop for sale should:

a) be free of food-borne infections or diseases;
b) maintain personal cleanliness, obey the rules of hygiene, and in particular often wash hands during work;
c) wear clean clothes and, where necessary, protective clothing;
d) injuries and abrasions should be treated with a waterproof dressing.

The producer shall ensure that persons involved in harvesting crops and preparing them for sale:

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

Hygiene requirements for crops prepared for sale

The plant producer shall take appropriate measures to ensure that:

a. clean water or water of the class intended for consumption is used to wash agricultural produce as required;
b. crops are protected during and after harvesting against physical, chemical and biological pollution.

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

A producer in an Integrated Crop Production system shall take appropriate measures to ensure that:

a) the rooms (including equipment), means of transport and packaging are kept clean;
b) farmed and domestic animals have no access to the rooms, vehicles and packaging;
c) harmful organisms (pests and organisms dangerous to humans), which may lead to contamination or pose a threat to human health, e.g. mycotoxins, are eliminated;
d) hazardous waste and substances are not stored together with crops prepared for sale.

11. PREPARATION FOR HARVESTING, HARVEST, AND POST-HARVEST PROCEDURE

Harvesting bean seeds is one of the most important activities. It belongs to species that do not pose great technical difficulties when harvesting, but seeds are easily damaged during threshing (Księżak and Podleśny 2002). Field bean can be harvested easily with a combine harvester, as in the case of determinate varieties, it ripens relatively evenly. Start harvesting when the pods and stems are blackened and dry. The harvest date usually falls in August, and in conditions of higher humidity in the north of the country, it may be delayed until September. If the course of the weather causes a delay in ripening, the harvesting of field bean should begin when about 80 % of the pods darken.

Harvesting field bean with a combine harvester reduces seed losses and labour inputs. The adaptation of the combine harvester for harvesting involves reducing the rotation speed of the threshing drum to 500-600 RPM, widening the gap between the drum and the concave to the maximum position, setting high fan speeds and openings, and selecting appropriate sieves. When adjusting, account should be taken, inter alia, of plant moisture, weeding, and lodging. If the weather is dry and sunny, the seeds may dry out (they may crack during harvesting). It is then necessary to collect them early in the morning or at night, reducing the drum speed to as low as 450 RPM.

After threshing, the seeds need to be cleaned and dried to 13–14 % moisture. Due to the possibility of damage to seeds in dryers, it is not allowed to reduce their moisture content by more than 3 % at a time. It should also be observed that the wetter the seeds are, the lower their drying temperature should be. Seeds containing 30 % water must be dried at a temperature not exceeding 30°C. After reducing the moisture content of the seeds to 25 % and then to 20 %, the air temperature must be raised to 35°C and 45°C, respectively. The drying of field bean seeds intended for feed should also not be carried out at too high a temperature, as the bioavailability of certain nutrients may deteriorate. Seeds should be dried in a warehouse with unheated air or by frequent shovelling of a thinly spread layer.

Bean straw remains in the field – before ploughing, when it is too long, it should be properly shredded (e.g. with a disc harrow).

12. DEVELOPMENTAL STAGES OF FIELD BEAN BASED ON THE BBCH SCALE

The BBCH scale is becoming more and more frequently used to determine the precise crop growth stages. It is appreciated by advisers and plant producers, primarily for its universality, because for all crops the same division of phenological phases has been used, and complex descriptions were replaced by suitable digital codes. The standard description of the development phases according to the BBCH has the same code, regardless of the language and country in which the scale is used. The two-digit code precisely determines the growth stage in which the plant is located. The first digit always determines the principal growth stage, and the second enables an even more precise determination of the growth stage and development of the crop. An arithmetically higher code indicates a later growth stage.

There are 8 main developmental stages of field bean: Stage 0 – Germination (emergence), Stage 1 – Leaf development, Stage 2 – Lateral shoot development, Stage 3 – Growth (elongation) of shoot, Stage 5 – Inflorescence development, Stage 6 – Flowering, Stage 7 – Pod and seed development, Stage 8 – Pod and seed ripening, Stage 9 – Plant aging and dying. It is worth noting that, unlike other plants, field bean does not have Stage 4 – Development of vegetative parts intended for harvesting.

The duration of individual developmental stages largely depends on the variety of field bean and agrotechnical and weather conditions. In particular, the stages associated with flowering, pod and seed formation, and their ripening may, depending on the conditions, be shortened or extended (developmental stages 5, 6, 7, 8). Weather conditions are also important for seed germination and uniform plant emergence (developmental stage 0). Generally, however, for field bean it is assumed that the period from sowing to emergence is 10-30 days (stage 0), from emergence to row closure is 30-40 days, the period from sowing to the beginning of flowering is 55-70 days, and the flowering stage (stage 6) lasts from 35 to 45 days. The entire growing period of field bean is approximately 110–140 days (Matysiak and Strażyński 2018).

CODE	DESCRIPTION
Principal growth stage 0: Germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Radicle has emerged from seed
07	Shoot emerges from the seed

08 Shoot grows towards the soil surface

09 Shoot breaks through the soil surface (soil cracking)

Principal growth stage 1: Leaf development

10 Visible pair of scaly leaves (sometimes they may be dried)

11 Expanded first leaf (1st lead unfolded)

12 2nd leaf unfolded

13 3rd leaf unfolded

1. Stages continue till…

19 9 or more leaves have unfolded

Principal growth stage 2: Development of lateral shoots (branching)

20 No side shoots

21 Beginning of lateral shoot development

22 2 side shoots

2. Stages continue until…

29 End of lateral shoot formation, 9 or more lateral shoots

Principal growth stage 3: Stem elongation (main stem)

30 Beginning of shoot growth

31 1st internode stage

32 2nd internode stage

33 3rd internode stage

3. Stages continue till…

39 9 or more visibly extended internodes

Principal growth stage 5: Appearance of inflorescence

50 Flower buds covered in leaves

51 Visible first flower buds protruding from the leaves

55 Visible first single flower buds above the leaves, still closed

59 Visible first petals, many single flower buds, flowers still closed

Principal growth stage 6: Flowering

60 First flowers opened (sporadically in population)

61 Open flowers on 1st inflorescence cluster

63 Open flowers on 3 inflorescence clusters

65 Full flowering: flowers open on 5 inflorescence clusters

67 Flowering finishing: most petals fallen or dry

69 End of flowering

Main development stage 7: Development of pods and seeds

70 First pods reach the typical length

71 10 % of pods have reached their typical length

72 20 % of pods have reached their typical length

73 30 % of pods have reached their typical length

75 50 % of pods have reached their typical length

77 70 % of pods have reached their typical length

79 All pods have reached the typical size, seeds completely formed

Principal growth stage 8: Ripening of pods and seeds

80 Beginning of ripening: green seeds

81 10 % of pods ripen, seeds turn brown and harden

83 30 % ripe and dark pods, brown and hard seeds

85 50 % ripe and dark pods, dark brown and hard seeds

87 70 % ripe and dark pods, dark brown and hard seeds

89 Full ripeness, almost all pods dark, seeds dry and hard

Principal growth stage 9: Senescence

93 Shoots begin to darken

95 50 % brown or black shoots

97 Plant dead and dry

99 Harvested product, dormancy

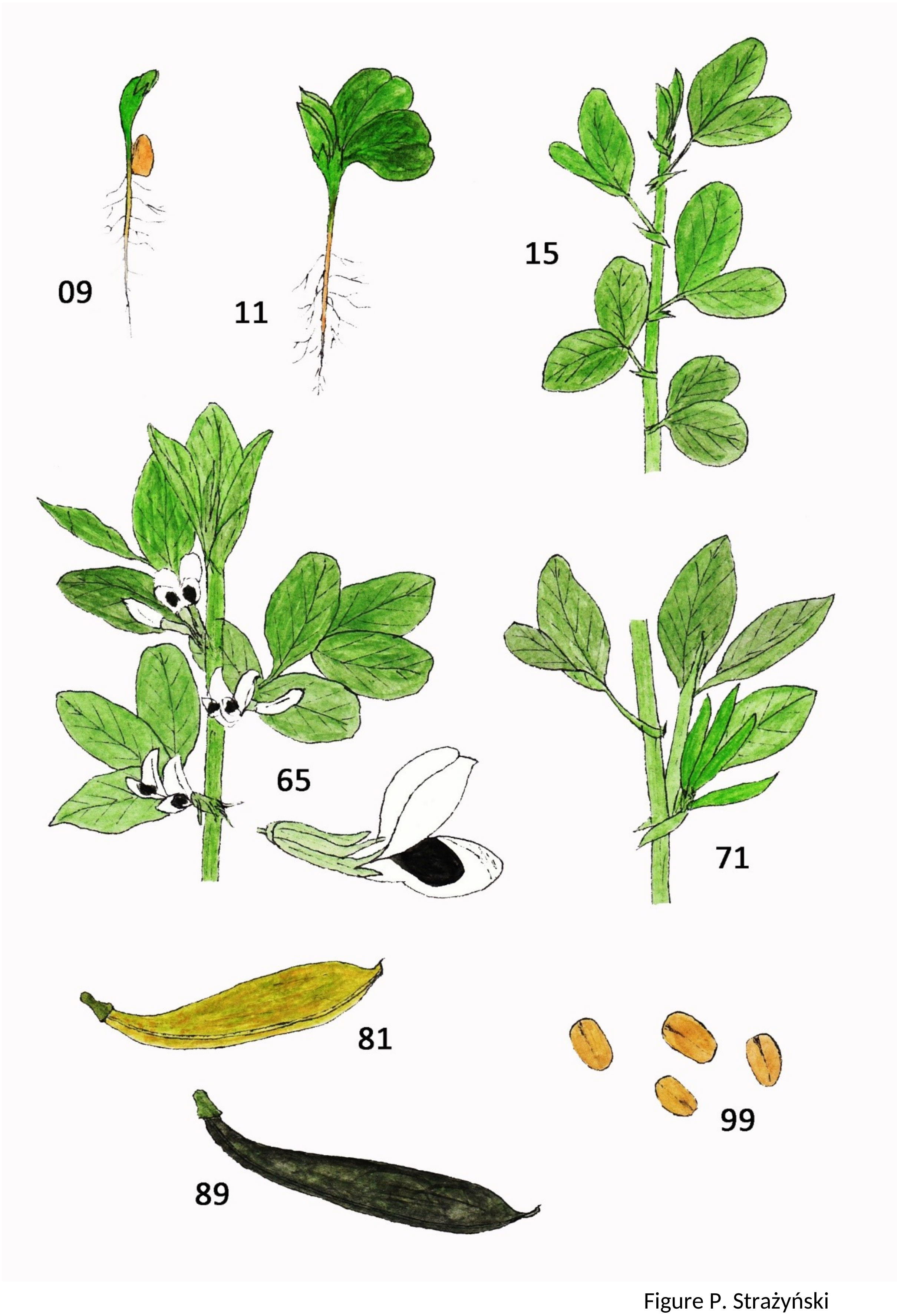

Figure P. Strażyński

13. RULES FOR KEEPING RECORDS IN INTEGRATED PRODUCTION

The cultivation of plants under the integrated plant production (IP) system is inextricably linked to the keeping or possession of various types of documentation by the agricultural producer. The IP Notebook is one of the most important of these documents. 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). The record-keeping rules will change on 1 January 2026 as a result of the application of Implementing Regulation (EU) 2023/564.

Other documents that a producer using integrated plant production must possess or may encounter 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;
- checklists;
- 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. The type of notebook is chosen according to the species of crop that has been declared to the certification body. 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/plots/greenhouses/tunnels in the integrated production system: in the table with the list of fields, record all cultivated varieties submitted for IP certification.

Field plan with biodiversity-increasing elements — graphically reproduce the plan of the farm and its immediate surroundings with the proportions of the various elements. On the farm plan, use the markings used as in the list of fields.

General information, sprayers, operators – enter the year in which the production started according to the principles of integrated plant production. Then move on to completing the table. Fill in the bulleted places with appropriate entries and confirm the information by ticking the boxes prepared for this purpose ( ). The 'Sprayers' table should be filled in with the required data and the information confirmed by ticking the relevant boxes (□). Note all sprayers operators carrying out plant protection treatments in the 'Sprayer operator(s)' table. It is absolutely necessary to indicate that the training in the use of plant protection products is up to date, including the date of completion (or other qualification). In the 'Sprayers' and 'Sprayer operator(s)' tables, all devices and persons performing treatments, including those performed by a service provider, are listed.

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

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

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

Seed (…): the table should be filled in with information about the purchased seed - species, 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/Planting – the table should be filled in with the recorded quantity of seed material used in each field. The dates of the activities carried out should also be recorded. For this purpose, it is required to tick the relevant boxes (□) to confirm the information on soil testing/assessment for existing pests which would exclude the field from IP cultivation.

Soil/substrate and plant analysis and fertilisation/fertigation — soil analysis is a fundamental activity to determine the fertiliser needs of plants. The IP producer must carry out such analyses and record them in the notebook. 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 green manures are used, the species or composition of the mixture is indicated in the ‘Type of fertiliser’ column. In the next table, ‘Soil mineral fertilisation and liming’, note the date and type and dose of fertilisation and liming applied and where it was applied. The ‘Observations of physiological disorders and foliar fertilisation’ table should be used to record observations regarding plant nutritional deficiencies and fertilisers applied. The IP grower must regularly inspect the crops for the occurrence of physiological diseases and record this fact each time. Foliar fertilisation should be correlated with the observations of physiological disorders carried out.

Control observations and record of plant protection treatments — the plant protection tables are the basic element of the IP Notebook. The first table ‘Observations of weather conditions and plant health’ is a detailed record of observations, in which we record the data indicated in the heading. In this table, the need for chemical treatment is also indicated. The next two tables are registers of plant protection treatments (agrotechnical, biological and chemical) and are closely correlated with the observation table. When carrying out this type of procedure, it is mandatory to record the name of the plant protection product or the biological or agrotechnical method applied, as well as the date and place of treatment. Table ‘Other chemical treatments applied (…)’ is a record of all treatments authorised for use on the crop that are not listed in the previous tables e.g. the use of desiccants.

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 pests set out in the integrated plant production methodologies.

Information on the cleaning of machinery, devices and equipment used in production, according to the requirements of the integrated production methodology — notebook page with the IP producer's space for information relating to the cleaning of machinery, devices and equipment used in the production, 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.

LIST OF MANDATORY ACTIVITIES AND PROCEDURES IN INTEGRATED PRODUCTION (IP) OF FIELD BEAN

Mandatory requirements (100 % compliance, i.e. 13 points)			
Item	**Checkpoints**	**YES/NO**	**Comment**
1.	Cultivation of field bean at least every 4 years in the same site (**see chapter 3.3**).	□/□	
2.	Selection of varieties according to COBORU guidelines (**see chapter 4**)	□/□	
3.	Use of seeds of at least the certified category with the appropriate seeding standard and parameters (**see chapter 4)**	□/□	
4.	Application of pre-sowing crop treatments according to the methodology (**see chapter 5.1**).	□/□	
5.	Inoculation of seeds with rhizobacteria immediately	□/□	

	before sowing ((**see chapter 5.2**).		
6.	Macro- and micronutrient fertilisation based on nutrient balance (**see chapter 6**).	□/□	
7.	Use of mechanical methods in pre- and post-emergence weed control (**see chapter 7.1.2**).	□/□	
8.	Systematic monitoring from the time of emergence to the beginning of ripening, at least once a week, for the occurrence of diseases (**see chapter 7.2.1**).	□/□	
9.	Systematic monitoring from the moment of emergence until the beginning of ripening, at least once a week, for pest incidence using appropriate methods (**see chapter 7.3.1., 7.3.2**).	□/□	
10.	Performance of at least one pest control treatment with a biological control product (**see chapter 8.**)	□/□	
11.	Creating the right conditions for the presence of birds of prey, i.e. setting up resting poles at a frequency of at least 1 for every 5 ha of plantation (**see Chapter 8**).	□/□	
12.	Placing of 'houses' for mason bees or mounds for bumblebees or other facilities for insect pollinators at a frequency of at least 1 pc for every 5 ha (**see chapter 8**).	□/□	
13.	Shredding and ploughing of post-harvest residues after harvest (**see chapter 11.**)	□/□	

Note:

The fulfilment of all the requirements in the list of mandatory operations and treatments under the integrated production scheme must be documented in the Integrated Crop Production Notebook.

14. CHECKLIST FOR AGRICULTURAL 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?	□/□	

Basic requirements (100 % compliance, i.e. 28 points)			
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 authorized for IP and use in a given crop or plant?	□/□	
12.	Is each use of plant protection products recorded in the IP Notebook taking into account the reason, date and place of use, the area of the crops, the dosage and the amount of the spray liquid per unit of area?	□/□	
13.	Were the plant protection treatments carried out under appropriate conditions (optimal temperature, wind below 4 m/s)?	□/□	
14.	Is the rotation of the active substances of the crop	□/□	

Basic requirements (100 % compliance, i.e. 28 points)			
	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 maximum number of treatments per growing season specified on the label of the plant protection product not exceeded?	□/□	
21.	Are the sprayers referred to in the IP Notebook in good technical condition and are their technical inspection certificates up to date?	□/□	
22.	Does the producer carry out systematic calibration of the sprayer(s)?	□/□	
23.	Does the producer have a separate space for filling and cleaning the sprayers?	□/□	
24.	Does the handling of residues of the spray liquid comply with the indications on plant protection product labels?	□/□	
25.	Are crop protection products stored in a marked closed room in such a way as to prevent contamination of the environment?	□/□	
26.	Are all plant protection products stored only in their original packaging?	□/□	
27.	Does the IP producer observe hygienic and sanitary principles, especially those specified in the methodologies?	□/□	
28.	Are appropriate conditions for the development and protection of beneficial organisms ensured?	□/□	

Basic requirements (100 % compliance, i.e. 28 points)		
Total points		

Additional requirements for field vegetable crops (minimum compliance 50 %, i.e. 8 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Were the plant varieties grown selected for Integrated Plant Production?	□/□	
2.	Is each box marked according to the entry in the IP notebook?	□/□	
3.	Did the producer perform all the necessary agrotechnical procedures in accordance with IP methodologies?	□/□	
4.	Is the recommended catch crop used in cultivation?	□/□	
5.	Are steps taken on the holding to reduce soil erosion?	□/□	
6.	Have the procedures been conducted using spraying devices specified in the IP notebook?	□/□	
7.	Are fertiliser application machines maintained in good working order?	□/□	
8.	Do fertiliser application machines allow for accurate dose determination?	□/□	
9.	Is each fertiliser applied recorded with regard to its form, type, date of application, quantity, location and surface?	□/□	
10.	Are fertilisers stored in a separate and specially designated room in a manner that ensures protection of the environment against contamination?	□/□	
11.	Does the producer protect empty PPP packaging against unauthorised access?	□/□	
12.	Does the producer have a dedicated place to collect organic and post-vegetable-sorting residues?	□/□	
13.	Are there first-aid kits near the workplace?	□/□	
14.	Are hazardous areas on the farm, e.g. plant	□/□	

	protection product storage rooms, clearly marked?		
15.	Does the producer use consultancy services?	□/□	
	Total points		

Recommendations (min. implementation 20 %, i.e. 2 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.	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?	□/□	
5.	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?	□/□	
6.	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?	□/□	
7.	Does the producer store on the farm only plant protection products allowed for use with the plant species they cultivate?	□/□	
8.	Does the producer improve their knowledge at Integrated Plant Production meetings, courses or conferences?	□/□	
	Total points		

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