MAIN INSPECTORATE FOR PLANT HEALTH AND SEED INSPECTION

DRAFT

Methodology

of Integrated Production of Winter and Spring Wheat

(*Triticum aestivum* L.)

(fifth edition, revised)

Approved

pursuant to Article 57(2)(2) of the Plant Protection Products Act of 8 March 2013

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by

the Main Inspector for Plant Health and Seed Inspection

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CONTENTS

1. PREFACE

Integrated plant protection consists of protecting crops against harmful organisms, using all available methods, in particular non-chemical ones, 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 (PPP) to a necessary minimum, thus reducing environmental pressure and protecting the biodiversity of the agricultural environment.

Professional users who apply plant protection products are obliged to take into account the requirements of integrated plant protection. An agricultural producer should use all available measures and methods of protection against pests before applying chemical plant protection methods with a view to reducing the use of pesticides. They consist in the application of crop rotation, the use of appropriate varieties, compliance with optimal timing, the application of appropriate agronomic practices, appropriate fertilisation, and the prevention of the spread of harmful organisms. One of the requirements is also to protect beneficial organisms and create favourable conditions for their occurrence, in particular pollinators and natural enemies. The use of chemical plant protection should be preceded by monitoring activities and supported by appropriate scientific instruments and advice.

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 complex than that of production using conventional methods. Natural biological mechanisms supported by the rational use of plant protection products are used under the integrated plant production scheme as much as possible. 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).

More information on registration in the integrated plant production scheme and the rules for issuing IP certificates is available on the website of the State Plant Health and Seed Inspection Service at https://www.gov.pl/web/piorin/zasady-ip.

2. CLIMATE AND SOIL REQUIREMENTS AND SITE SELECTION

2.1. Climate

Winter wheat

Winter wheat is a long-day plant. Its proper growth is significantly influenced by temperature. Throughout the growing period, the sum of temperatures should be 1248°C. During the autumn growing season, depending on the developmental stage, wheat has varying requirements for this factor. The optimum temperature – from sowing to emergence – is 11.6 °C/day and 1 to 5 leaves – 6.3 °C. During the winter resting period – 2 °C. In the spring following resumption of vegetation – 9 °C, while during the grain pouring period, it increases to 16 °C.

Winter wheat is a crop whose yield depends largely on water conditions. During the autumn growing season, it requires monthly precipitation of around 45 mm. During the winter dormancy period, precipitation should be about 10 mm per ten days. Following the resumption of growth in spring, wheat requires 13 mm of rainfall per decade up to the heading stage, and 27 mm per decade after heading.

Spring wheat

Spring wheat is a crop that is highly sensitive to air temperature. Most often, as a result of the rapid increase in temperature, there is a significant drop in yield. From sowing to the tillering stage, the optimum temperature is 6–8 °C. During the stem elongation stage, the temperature requirements for spring wheat increase slightly – to 14 °C. Above this temperature, yield decreases. The situation is similar during the grain-filling period. In this case the temperature should not be higher than 17 °C.

The yield of spring wheat is largely determined by the amount of rainfall and its distribution. Heavy soils should have a minimum rainfall of 200 mm and medium soils a minimum rainfall of 240 mm. The distribution of rainfall is expected to be as follows: April – 19 %, May – 27 %, June – 29 %, July – 25 %.

2.2. Soil

Winter wheat

Winter wheat is characterized by high soil requirements. The most suitable soils for its cultivation are: chernozems, black earths, brown soils, deep rendzinas and alluvial soils characterised by a good depth of topsoil. It grows and yields best in soils of the following types: very good, good and poor wheat soils; very good rye soils; strong fodder cereal soils; mountain wheat soils; and mountain cereal soils. Bonitation classes: I-IIIb. The soil pH should be close to neutral: pH_{KCl} 6.0–6.8; the agrotechnically acceptable range is 5.3–7.3. The soil should have a good structure and a balanced water-air ratio.

Spring wheat

Spring wheat should be grown on compact soils belonging to the very good wheat complex or the good wheat complex, or on medium soils (the very good rye complex, the defective wheat complex or, as a last resort, the good rye complex), provided that it follows a suitable preceding crop. Since wheat is sensitive to acidic soil, the pH should be at least 5.7 on medium soils and 6.0 on good soils.

2.3. Precursor crops

Winter wheat

Precursor crop affects the level of winter wheat yield and grain quality by affecting the fertility of the soil, enabling soil preparation and sowing of plants in the optimal time, and reducing the occurrence of diseases, pests, and weeds. In integrated production, precursor crops are divided into three categories: best, good and worst. When growing winter wheat under an integrated production system, the crop should be established only after ‘best’ or ‘good’ preceding crops, and there should be an interval of at least one year between wheat crops.

Best precursor crops: legumes, field bean, soya, edible and fodder peas, vetches, white lupin, narrow-leaved and yellow lupin (provided that they are grown on soils suitable for winter wheat), perennial legumes (clover, alfalfa) and mixtures of clover with grasses, winter and spring oilseed rape, potatoes, beets grown for early harvest, vegetables, e.g. winter onions.

Good precursor crops: maize grown for silage, maize grown for grain (provided that the harvest date allows for the preparation of the field and sowing of winter wheat within the required time limit), sunflower, sugar and fodder beet (provided that the harvest date allows for the preparation of the field and sowing of winter wheat within the required time limit), blue tansy (provided that it is grown on soils suitable for growing winter wheat), oats (provided that they are grown on soils suitable for growing winter wheat), white, black and sarepta mustard (provided that they are grown on soils suitable for growing winter wheat), buckwheat (provided that they are grown on soils suitable for growing winter wheat).

Worst precursor crops: all winter and spring cereals (except oats).

Spring wheat

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<u>Best precursor crops</u>: sugar and fodder beets, potatoes, legumes, edible and fodder peas, field bean, soya, white lupin, narrow-leaved and yellow lupins (provided that they are grown on soils suitable for growing spring wheat), perennial legumes (clover, alfalfa) and mixtures of clover with grasses, winter and spring oilseed rape, vegetables.

<u>Good precursor crops</u>: maize cultivated for silage and grain, sunflower, white mustard, black and sarepta mustard, oats (cultivated on soils suitable for spring wheat cultivation), blue tansy (provided that it is grown on soils suitable for spring wheat cultivation), buckwheat (provided that it is grown on soils suitable for spring wheat cultivation).

<u>Worst precursor crops</u>: all winter and spring cereals (except oats).

3. SELECTION OF WHEAT VARIETIES IN INTEGRATED PRODUCTION

Cultivating varieties that are resistant to or tolerant of harmful organisms is one of the basic principles of integrated wheat protection. Varietal resistance to harmful organisms (diseases and pests) is increasingly important in more environmentally-friendly cultivation systems. By design, they aim to minimise the application of plant protection products in plant cultivation. In sustainable crop production, disease-resistant/tolerant varieties are a special and pro-ecological means of production. Therefore, breeding such varieties is essential for the popularisation of integrated wheat protection and production. This issue also has an important economic aspect. On one hand, each plant protection treatment increases the cost of cultivation, while on the other hand, application of a suitable treatment, e.g. with a fungicide, can improve the health of plants and thus prevent the loss of part of the yield and compensate for the expenses incurred.

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

Detailed information on the selection of varieties indicated for IP by the RCFCT can be found in the list at coboru.gov.pl/pdo/ipr.

variety is selected from the CCA catalogue, its selection should be justified in accordance with the IP objectives.

4. PRE-SOWING TILLAGE AND SOWING

4.1. Soil cultivation

Winter wheat

Work on preparing the field for winter wheat cultivation should begin early, immediately after harvesting the precursor crop. The type of crop and its elements vary greatly depending on the technology in which the wheat will be grown. In integrated production, wheat can be grown using both traditional ploughing and conservation tillage systems. However, it is prohibited to grow wheat using the zero-till system. Depending on the technology, the cultivation consists of different treatments.

The traditional ploughing system consists of the following:

- post-harvest cultivation — must be carried out carefully so that all post-harvest residues are well and finely shredded. This is due to the fact that pathogens and pests may be present on their surface. Furthermore, thorough post-harvest tillage helps to reduce evaporation, thereby protecting the soil from water loss. As a result of professionally carried out cultivation, weed seeds are stimulated to germinate, and the emerging weeds are mechanically destroyed through subsequent treatments;
- seedbed ploughing — must be carried out at a depth of between 18 and 24 cm. The depth depends on the type of soil. On lighter soils, ploughing should be carried out at a shallower depth, and on heavier soils at a deeper depth. Ploughing should be carried out 3-4 weeks before the planned sowing. When ploughing cannot be performed in advance, a ring shaft should be used to accelerate the subsidence of the soil;
- pre-sowing cultivation — these cultivation operations are designed to mix in mineral fertilisers and prepare the soil for sowing.

Conservation cultivation consists of the following:

- post-harvest cultivation — must be carried out carefully so that all post-harvest residues are well and finely shredded. This is due to the fact that pathogens and pests may be present on their surface. Furthermore, thorough post-harvest tillage helps to reduce evaporation, thereby protecting the soil from water loss. As a result of professionally conducted cultivation, weed seeds are stimulated to germinate. The emerging weeds are destroyed during the next crop treatment. This treatment differs slightly from the previous one, as the field should be well levelled and its deeper layers loosened during the process. Proper loosening of the deeper soil layers without turning them over, as occurs in traditional cultivation systems, allows the root system of the crop to develop correctly;
- pre-sowing cultivation — the purpose of pre-sowing cultivation in conservation tillage is the mixing of fertilisers, the levelling of the field and the compaction of the topsoil in which the grain will be placed.

Strip till — the second type of conservation crop. It consists in loosening the strip of soil without turning it. This cultivation is carried out in conjunction with the sowing of seed and the application of mineral fertilisers. The use of strip tillage leads to a significant reduction in costs and helps to conserve the soil's water resources.

Spring wheat

Work on the preparation of the field for spring wheat should be started early, immediately after the harvest of the precursor crop. The type of crop and its elements are significantly different depending on the technology in which the wheat will be grown and the precursor crop. In integrated production, wheat can be grown using both traditional ploughing and conservation tillage systems. However, it is prohibited to grow wheat using the zero-till system. Depending on the technology, the cultivation consists of different treatments.

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- pre-winter ploughing — ploughing should be carried out to the depth of the humus layer, which, depending on the soil type, is 25–30 cm;
- spring cultivation — the spring preparation of the field should start as soon as it is possible to enter the field. The first works aim to secure the water accumulated in the soil profile during the winter, as well as to accelerate the heating of the soil. A leveller or spike-tooth harrow is used for this purpose. Subsequent cultivation treatments aim to prepare the soil for placing seed.

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- post-harvest cultivation — must be carried out carefully so that all post-harvest residues are well and finely shredded. This is due to the fact that pathogens and pests may be present on their surface. Furthermore, thorough post-harvest tillage helps to reduce evaporation, thereby protecting the soil from water loss. As a result of professionally conducted cultivation, weed seeds are stimulated to germinate. The emerging weeds are destroyed during the next crop treatment. This treatment differs slightly from that used in the ploughing system, as the field must be well levelled and cover crops sown during its execution. Cover crops should be sown in late August or early September. The following plants are most commonly included in a cover-crop mixture: blue tansy, mustard and various species of legumes. Cover crops left in the ground over winter are destroyed by low temperatures, and their remains form a mulch that protects the soil from wind and water erosion, as well as from the leaching of nutrients. If spring wheat is grown after precursor crops that leave the field late, cover crops are not grown. In this case, the deeper layers of the soil should be thoroughly loosened without turning it over. Deep soil disturbance will facilitate the proper development of the roots;

– spring tillage — in conservation tillage, spring tillage varies depending on how the mulch is handled. In the event of its destruction, a cultivation unit should be used, the purpose of which is to mix mulch and mineral fertilizers with the soil, as well as to prepare the soil for sowing. In a situation where cover crops have not been sown, the purpose of spring cultivation is to mix fertilisers and to prepare the soil for placing the grain in it;
– Strip till — the second type of conservation crop. It consists in loosening the strip of soil without turning it. This cultivation involves the sowing of seed and the application of mineral fertilisers. The use of strip tillage leads to a significant reduction in costs and helps to conserve the soil's water resources.

4.2. Sowing

Only seed material of at least the qualified category shall be used for sowing, and proofs of purchase must be kept for inspection.

Winter wheat

The sowing of winter wheat in an integrated production system, regardless of the region, must be carried out within an optimal time frame.

Under the IP system for winter wheat, however, a 5-day advance or a 14-day delay in sowing from the calendar date set for a given region is permitted. However, it is necessary to indicate the reason for the derogation from the optimal sowing time. The sowing of winter wheat in the integrated production system must not begin before 10 September in the regions where sowing begins at the earliest and after 30 October in the regions where sowing must take place at the latest. This is because winter wheat does not respond well to sowing either too early or too late. If sowing takes place too early, the plants will produce too many above-ground parts before winter sets in. This situation will make them more vulnerable to pest attacks. Delayed sowing means that winter wheat will not reach the tillering stage in autumn, nor will the differentiation of the growing point begin before winter. As a result of delayed sowing, all shoots are shortened, especially the lateral ones. It should be borne in mind that delayed sowing adversely affects all three elements of the yield structure: the number of logs, the number of grains in the log and the weight of a thousand grains. The delayed sowing date negatively affects the wintering of winter wheat.

Optimal plant density of winter wheat is 500-700 ears/m^2. In order to obtain such a density of ears, a sufficient number of grains must be sown per surface unit. The number of seeds sown depends on: the sowing date, the variety and the fertility of the soil. Consequently, the number of seeds sown ranges from 300 to 450 per $metre^2$. For early sowing, the recommended number of seeds to be sown is 300 per m^2, and for late sowing, 400–450 per m^2. The seed rate is determined by taking into account the plant density per 1 m^2, the weight of 1,000 seeds (WTS), and the seed quality — germination rate (%).

$$Sowing(kg/ha)=\frac{Plant\,density\ per\,1\,m2\ X\ WTS[g]}{Germination\,capacity[\%]}$$

Winter wheat is sown at a depth of 2–4 cm. The row spacing for winter wheat, depending on the variety and the plant density per unit area, ranges from 10 to 20 cm. Most often, however, wheat is sown with a row spacing of 15 centimetres.

Spring wheat

The sowing of spring wheat in an integrated production system, regardless of the region, must be carried out within an optimal time frame.

However, under the IP system for spring wheat, sowing may take place up to 10 days earlier or later than the calendar date specified for a given region. However, it is necessary to indicate the reason for the derogation from the optimal sowing time. The sowing of spring wheat in the integrated production system must not begin before 5 March in regions where sowing starts at the earliest and after 20 April in regions where sowing must be carried out at the latest. This is because spring wheat does not respond well to sowing either too early or too late. Sowing too early will cause the plants to be damaged by frost. Delayed sowing means that the wheat will face adverse weather conditions (excessively high temperatures and water shortages) that will hinder its proper development. In addition, the various development phases will be shortened, which will have a negative impact on the size and quality of the yield.

Optimal plant density of winter wheat is 550-600 ears/m^2. In order to obtain such a density of ears, a sufficient number of grains must be sown per surface unit. The number of seeds sown depends on: the sowing date, the variety and the fertility of the soil. Consequently, the number of seeds sown ranges from 400 to 600 per $metre^2$. For early sowing and on good soils, the recommended number of seeds to be sown is 400 seeds/m^2, whilst for late sowing and on poorer sites, it is 600 seeds/m^2. The seed rate is determined by taking into account the plant density per 1 m^2, the weight of 1,000 seeds (WTS), and the seed quality — germination rate (%).

$$Sowing(kg/ha)=\frac{Plant\,density\ per\,1\,m2\ X\ WTS[g]}{Germination\,capacity[\%]}$$

Spring wheat is sown at a depth of 3–5 cm. Wheat should be sown shallower on better (heavier) soils and deeper on lighter sites. The spacing between the rows of spring wheat is usually 15 cm. However, in justified cases, spring wheat may be sown in a different row spacing.

5. SUSTAINABLE FERTILISATION SYSTEM FOR WINTER AND SPRING WHEAT

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

5.1. Nutritional needs

Winter wheat

Fertilization of winter wheat affects the size of the crop and the quality of the grain. In order to ensure that winter wheat plants receive an adequate supply of nutrients, soil tests should be carried out regularly (once every four years) to determine the soil's pH and its content of essential macronutrients — N, P, K and S. The tests should be carried out at an accredited laboratory, preferably at an Agricultural Chemistry Station. Up-to-date test results for a given field are essential to obtain correct nutrient balancing and determine fertiliser rates.

Micronutrients are mainly applied in a foliar manner as such fertilisation significantly increases their use by plants and more effectively counteracts their deficiencies during critical stages and under conditions that are not favourable for the uptake of nutrients from the soil. Many factors (soil pH, temperature, soil moisture) can limit the availability and assimilability of particular micronutrients. It should also be borne in mind that with an inadequate supply of micronutrients, deficiency symptoms on plants may not be visible and the application of micronutrients at the onset of symptoms is not always effective. Micronutrient prophylaxis is therefore necessary to guarantee the availability of micronutrients to plants at every stage of their development. Preventive micronutrient fertilisation should receive attention, especially on farms where natural fertilisers are not used. When growing winter wheat in an integrated system, there is no obligation to examine the soil for the content of micronutrients.

Winter wheat with a yield of 1 tonne of grain and an appropriate amount of straw takes on average the following amounts of macronutrients: 26-30 kg of nitrogen (N), 11 kg of phosphorus (P_2O_5), 19 kg of potassium (K_2O), 5 kg of calcium (CaO), 4 kg of magnesium (MgO), 9 kg of sulphur (SO_3) and micronutrients: 5 g of boron (B), 8.5 g of copper (Cu), 270 g of iron (Fe), 82 g of manganese (Mn), 0.7 g of molybdenum (Mo), 60 g of zinc (Zn).

Note: winter wheat is highly sensitive to copper and manganese deficiency. Manganese deficiency occurs most often on freshly calcified soils and when the soil pH is above 6.5.

Spring wheat

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Spring wheat with a yield of 1 tonne of grain and an appropriate amount of straw takes on average the following amounts of macronutrients: 23-30 kg of nitrogen (N), 9-13 kg of phosphorus (P_2O_5), 16-24 kg of potassium (K_2O), 5-6 kg of calcium (CaO), 3-4 kg of magnesium (MgO), 9 kg of sulphur (SO_3) and micronutrients: 5.5 g of boron (B), 8.5 g of copper (Cu), 360 g of iron (Fe), 110 g of manganese (Mn), 0.7 g of molybdenum (Mo), 70 g of zinc (Zn).

Note: spring wheat is highly sensitive to copper and manganese deficiency. Manganese deficiency occurs most often on freshly calcified soils and when the soil pH is above 6.5.

5.2. Soil pH analysis

Winter wheat

Work on pH regulation of soils should be carried out early, at least 6 weeks before winter wheat sowing. The appropriate pH is a very important factor affecting the yield size and quality of the grain. Therefore, if necessary, liming must not be neglected. Thanks to liming, there is an improvement in the uptake of nutrients and the development of the root system. In a situation where liming was not applied before sowing, it is necessary to catch up by secondary lime application in spring or winter. The application of lime should be carried out separately from the application of nitrogen fertilisers.

Spring wheat

Work to regulate the pH of the soils before sowing spring wheat should be carried out early, after the precursor crop has been harvested. It is best to apply lime in late summer or early spring, making sure to mix it thoroughly into the soil. If lime needs to be applied in the spring, it is best to spread it before sowing spring wheat and before applying nitrogen fertilisers. When applying lime on the surface, it is important to use granulated calcium carbonate lime.

The Integrated Production scheme prohibits the use of sewage sludge, post-fermentation product sludge and other sludge of unknown composition for fertilisation purposes due to the specific nature of IP production rules, which are more stringent than those applicable to conventional production.

6. INTEGRATED PROTECTION AGAINST PESTS

6.1. Weed infestation control

The protection of winter and spring wheat against weed is one of the key factors determining the profitability of its production. Weed infestation occurs when weeds are present in quantities or masses which directly or indirectly cause economic losses, e.g. as a result of a significant reduction in the quality or quantity of yield, delay of harvesting, or reduction in the efficiency of machinery.

The harmfulness of weed infestation is significantly influenced by agrotechnical treatments, biology, and rhythm of weed development as well as the potential of the crop to compete with weeds and from environmental conditions, including soil type, availability of nutrients, and the course of hydrothermal conditions during the growing season.

In the development of the crop, the so-called ‘critical period of weed competition’ can be distinguished when the crop is most susceptible to weeds. In winter and spring wheat, this is usually the time interval from sowing to the beginning of the stem elongation stage. The various botanical forms and wheat varieties, due to the different morphological characteristics, show different potential in competing with weeds. Morphological characteristics favouring competitiveness in relation to weeds include in particular: energy and germination capacity, production tillering potential, foliage area, and blade length. These features affect, among other things, the development, architecture of the field. The large vigour of the plants as well as the dynamic growth and formation of compact benches has an impact on reducing the penetration of solar radiation, and under conditions of shading, emergence and development of weeds shall be limited. However, the ability to compete with weeds is not due to the individual characteristics of the crop but to interaction among them.

In the weed infestation regulation, agrotechnical methods should be used in the first place. If chemical protection is necessary, it is extremely important to use the herbicide at the right dose taking into account the sensitivity level of weeds developed for single-occurring weeds or their communities.

6.1.1. The most important weed species occurring in winter cultivation

Weeds are a permanent part of arable fields. Weeds are usually those plants which are not the object of cultivation, but which grow on plantations against the will of the host. Most often these are species of segetal or ruderal plants as well as self-sown crops (Table 1).

Among weeds, the greatest harm is displayed by species that are characterised by rapid development and high reproductive potential. The species composition of weed infestation and the number of weeds are mainly shaped by agrotechnical activities. The botanical composition of weed infestation most often includes from 5 to 10 species.

In winter wheat, monocot weed species such as loose silky-bent, black-grass, rye brome, and under conservation tillage conditions also rye brome, are becoming an increasing problem. Locally, an infestation of common couch grass may be a problem. Among the dicot weeds found in winter wheat crops, the most common species include small-flowered crane's-bill, common mugwort, field poppy, cornflower, field pansy, speedwells, and sea mayweed. In spring wheat, the weed infestation is more often dominated by dicot weeds with a fast growth rate or occurring in large numbers, mainly: lamb's quarters, wild buckwheat and field pansy. On the other hand, weed infestation with monocot species is local in nature.

The large presence of weeds on weed-infested fields is due to their adaptability to habitat conditions, their high multiplication rate (i.e. they produce a very large number of seeds), and their ease of self-spreading. Their uncontrolled occurrence leads to weed infestation which is undesirable for many reasons.

Table 1. Occurrence and importance of selected weed species in wheat

Weeds	Winter wheat	Spring wheat
Small-flowered crane's-bill – *Geranium pusillum* L.	++	+
Common mugwort — *Artemisia vulgaris* L.	+	+
Cornflower — *Centaurea cyanus* L.	++	+
Cockspur — *Echinochloa crus-galli* (L.) P. Beauv.	-	+
Common fumitory — *Fumaria officinalis* L.	+	+
Small bugloss — *Anchusa arvensis* (L.) M. Bieb.	+	+
Field pansy — *Viola arvensis* Murr.	++	++
Field mustard — *Sinapis arvensis* L.	+	+ +
Common chickweed — *Stellaria media* (L.) Vill.	++	++
Deadnettle – *Lamium* spp.	+	+
Lamb's quarters — *Chenopodium album* L.	+	+++
Field poppy — *Papaver rhoeas* L.	++	+
False mayweed – *Matricaria maritima* L.	+++	+
Common windgrass — *Apera spica-venti* (L.) P. Beauv.	+++	+
Field forget-me-not — *Myosotis arvensis* (L) Hill.	+	+
Creeping thistle — *Cirsium arvense* (L.) Scop.	+	+
Common wild oat — *Avena fatua* L.	-	+ +
Couch grass — *Elymus repens* (L.) Gould	+	+

Persian speedwell — *Veronica* spp.	++	+
Catchweed — *Galium aparine* L.	+++	+
Wild buckwheat — *Fallopia convolvulus* (L.) Á. Löve	+	++
Field chamomile — *Anthemis arvensis* L.	+ +	+
Wild radish — *Raphanus raphanistrum* L.	+	++
Self-sown rape	++	+
Flixweed — *Descurainia sophia* (L.) Webb ex Prantl.	+	+
Brome — *Bromus* L. sp.	+/++	+
Shepherd's purse — *Capsella bursa-pastoris* (L.) Medik.	++	+
Field pennycress — *Thlaspi arvense* L.	++	+
Slender meadow foxtail — *Alopecurus myosuroides* Huds.	+/++	+

(+++) harmfulness very high, (++) harmfulness with numerous occurrences, (+) low or locally significant harmfulness, (-) no or marginal occurrence

6.1.2. Methods for monitoring weeds in wheat cultivation

Monitoring of weed occurrence is an important element of integrated weed protection. Planning and decision on chemical control of weeds should be made on the basis of current inspections of the plantation. Chemical herbicides should be used according to the information provided in the label of the plant protection product and the dose of herbicide(s) should be selected according to the current state of weed (species and quantity of weeds) and the development stage of weeds and arable crops.

When planning the selection of herbicide, it is also important to take into account the history of weed infestation of the field in earlier years, because unlike the seeds of arable crops that rise quickly and evenly after sowing, germination of weed colonies is spread over many months or even years. This should be taken into account when planning both the selection of the herbicide, date, and dose of its use.

6.1.3. Agrotechnical methods for controlling weed infestation

In integrated production, the regulation of weed infestation consists in the use of indirect, preventive, and direct methods based on intervention measures. Indirect methods include: appropriate rotation of crops (crop rotation), agrotechnics, and selection of varieties and quality of seed as well as dates of sowing, plant density taking into account the environmental and climatic conditions and the requirements of the variety of the arable crop. Intervention measures consist in direct control of weeds before and after the crop emergence. All agrotechnical treatments should be carried out with clean tools, free of weed seeds and organs of their vegetative reproduction.

The main source of weeds are colonies (seeds, rhizomes, cleavages, bulbs) of weeds in soil, usually called '*soil seed bank*'. These are the so-called 'potential weed infestation'. The soil bank contains seeds and other reproductive organs capable of germination and accumulated in the crop layer. In favourable conditions, they germinate, and developing seedlings create the so-called 'current weed infestation'. Therefore, as the basis of weed control, it is important to perform measures aimed at reducing the number of viable weed colonies in the soil. This can be achieved by, among others, mechanical tillage, for example, during post-harvest tillage. During mechanical cultivation under certain conditions (e.g.: light impulse, change of temperature and aeration), there are processes in weed colonies that activate the germination process. Following subsequent agrotechnical treatments destroying weed seedlings, the resources of the soil weed seed bank are reduced. It should be noted that the spread of weeds is also a consequence of agricultural activity, for example by sowing uncertified seed contaminated with weed seeds. This leads to the enrichment of the soil stock of weed seed bank, often with new species, and in extreme situations with biotypes of weeds resistant to herbicides.

In integrated production, weed infestation control should be carried out using indirect, preventive methods and direct, intervention-based methods, e.g. through the application of the following:

- appropriate site selection for wheat cultivation, taking into account the correct crop rotation;
- control of weeds in the post-harvesting unit;
- cultivation treatments performed as necessary and in such a way as to avoid pulverising and drying out the soil;
- broadly understood prevention, including regular cleaning of cultivating and harvesting machinery, in order to prevent the spread and sowing of weeds;
- wheat varieties on the basis of recommendations and studies of the Research Centre for Cultivar Testing (RCFCT);
- certified seed; adequate seed quality ensures rapid, even emergence and planned plant density when sowing is carried out under optimal conditions (sowing date, sowing depth, soil temperature and moisture);
- mechanical weed control in wheat crops based on harrowing.

6.1.4. Chemical methods of weed infestation control

Effective action of herbicides depends on the correct identification of weeds, selection of a suitable remedy and timely execution of the treatment.

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 plant protection products authorised for integrated production is available in the Pest Alerting Platform: https://www.agrofagi.com.pl/133,wykaz-srodkow-ochrony-roslin-do-integrowanej-produkcji-w-uprawach-rolniczych.

6.2. REDUCTION OF DISEASE VECTORS

6.2.1. The most important diseases in wheat cultivation

Wheat, especially its winter variety, is exposed to diseases caused by pathogenic fungi and other pathogenic organisms. The most common in wheat cultivation are: leaf septorioses (septoriosis striped wheat leaves and septoria nodorum blotch — symptoms on the leaves), powdery mildew of cereals and grasses, and brown rust. Yellow rust and brown leaf spot (DTR) are becoming increasingly important in the era of climate change. Diseases of the base of the blade, and especially fusarium stem base and root rot can also pose a high risk. It may be dangerous for consumers to have fusarium blight of ears whose perpetrators (mushrooms of the *Fusarium* spp. genus) can produce harmful metabolites. **In integrated wheat production, it is mandatory to systematically monitor the field in the stage of tillering/stem elongation, flag leaf, heading in order to assess the occurrence of diseases (powdery mildew and of cereals and grass, leaf septorioses, brown rust, brown leaf spots, yellow rust) with particular emphasis on fusarium blight of ears after heading.** Other pathogenic organisms, such as bacteria, viruses and phytoplasmas, may also be present in the cultivation of this species. The incidence of diseases caused by pathogenic organisms reduces wheat yield by an average of 5-10 %. However, locally, the amount of losses may be greater and this is related to the weather conditions occurring during the growing season.

The current threat posed by pathogenic organisms is shown in Table 2. The risk to the loss of wheat yield and its quality is a dozen diseases. Depending on the disease, they are caused by one or more pathogenic organisms. They can pose different risks and are difficult to diagnose, especially when there are two or more disease entities on a plantation at the same time. They are present in the cultivation of wheat from the germination stage to the ripe stage of the grain.

Table 2. Economic importance of winter and spring wheat diseases in Poland

Disease	**Pathogen(s)**	**Potential threat**	
		Winter wheat	Spring wheat
Brown leaf spot	*Pyrenophora tritici-repentis*	++	+
Sooty mould black mould on wheat ears	*Alternaria* spp., *Cladosporium* spp., *Epiccocum* spp., *Ascochyta* spp.	+	+
Fusarium blight of ears	*Fusarium* spp.	++	++
Fusarium blight of leaves	*Fusarium* spp.	+	–
Fusarium stem base rot and root rot of cereals	*Fusarium* spp.	+++	+
Loose smut of wheat	*Ustilago tritici*	+	–
Cereal stem breakage	*Oculimacula* spp.	+++	+
Powdery mildew of cereals and grass	*Blumeria graminis*	+++	++
Soil-borne rhizoctonia infection (rhizoctonia)	*Ceratorhiza cerealis*, *Rhizoctonia solani*	++	–
Snow mould	*Microdochium nivale*	++	–
Brown rust of wheat	*Puccinia recondita*	++	+
Yellow rust	*Puccinia striiformis*	++	++
Wheat leaf banded septoriosis	*Mycosphaerella graminicola*	+++	+

Septoria nodorum blotch of wheat	*Phaeosphaeria nodorum*	++	+
Ergot of cereals and grasses	*Claviceps purpurea*	+	–
Common bunt	*Tilletia Caries*	++	–
Stem base rot blight	*Gaeumannomyces graminis*	++	–
Seedling blight	complex of pathogens	++	+

+ disease of local importance; ++ important disease; +++ very important disease; — disease without significance

In integrated production, measures to reduce the occurrence of diseases can be undertaken by the agricultural grower in various ways. Ideally, the approach to protection should be comprehensive. It consists in combining methods of protection useful in controlling the perpetrators of diseases: agrotechnical, cultivation, biological, and chemical as the last resort.

6.2.2. Methods for monitoring disease perpetrators in wheat cultivation

Weather conditions, especially humidity conditions and the amount and distribution of rainfall during the growing season, temperature and sunshine play a significant role in the severity and timing of disease outbreaks. Disease pressure increases in monoculture and crop rotations with a high proportion of cereals, with simplified tillage, excessively dense sowing, and weed infestation. Susceptibility of the variety to paralysis is an important factor facilitating the development of pathogens. Disease infections are also facilitated by high nitrogen fertilisation and macro- and micronutrient deficiencies. Abiotic stress and pest damage to plants also have an impact, facilitating plant infestation.

In the integrated method, it is advisable to know the sources of infection and conditions that are conducive to the occurrence of diseases. This is helpful in determining the precise timing of a treatment. It also allows the severity of certain diseases to be reduced in subsequent years through measures such as agrotechnical treatments, sowing varieties resistant to pathogen infestation and using varieties that do not lodge.

Details regarding the aetiology of the pathogens responsible for specific diseases and the symptoms they cause can be found, amongst other places, in the 'Rapeseed Protection Alert Guide' at https://www.agrofagi.com.pl/plik,1152,poradnik-sygnalizatora-ochrony-zboz-pdf.pdf.

6.2.3. Agrotechnical methods of reducing pathogens

The application of the agrotechnical method is based on the correct and timely execution of crop planning and management. A properly selected precursor crop allows to reduce sources of pathogen infection. A break in wheat cultivation radically reduces the risk of diseases, e.g. the base of the blade. The sowing date, the amount of seed sown per m^2 and the distance between grains in the row are also important. The use of rational fertilisation, especially with nitrogen, reduces the risk of real grain and grass powder, for example. The right harvest date also influences the presence of fungi in the crop, on the straw or stubble.

The measures mentioned above (Table 3) that are implemented in the agrotechnical method make it possible to greatly reduce the risk of diseases caused by fungi. It is advisable to use as many elements as possible that reduce the occurrence of diseases. Wheat which grows and develops in optimal conditions shall enable obtaining a satisfactory yield, both in terms of quality and quantity.

Table 3. Agrotechnical methods for limiting the most important wheat diseases

Disease	**Key agrotechnical limitation measures**
Brown leaf spot	destruction of post-harvesting residues, use of treatments to accelerate the mineralisation of post-harvesting residues
Sooty mould black mould on wheat ears	appropriate crop rotation; destruction of crop residues; spatial isolation – the distance between spring and winter plantations; optimal fertilisation with reduced N dose; optimal harvesting date
Fusarium blight of ears	appropriate crop rotation, careful mixing of crop residues with soil, destruction of volunteer plants and optimisation of nitrogen fertilisation
Fusarium blight of leaves	use of certified seed, elimination of primary sources of infection, thorough incorporation of crop residues into the soil, and proper fertilization (maintaining the appropriate NPK ratio)
Fusarium stem base and root rot	appropriate crop rotation, careful ploughing in of crop residues, destruction of volunteer plants
Loose smut of wheat	use of healthy, teliospor-free sowing seeds
Cereal stem breakage	crop rotation, careful mixing of crop residues with soil, destruction of volunteer plants and optimisation of nitrogen fertilisation
Powdery mildew of cereals and grass	thoroughly mixing of crop residues into the soil, destruction of volunteer plants, maintaining proper seeding density, balanced fertilization (avoiding excess nitrogen), and avoiding the planting of spring grains in the vicinity of winter grains.
Soil-borne rhizoctonia infection (rhizoctonia)	correct crop rotation, agrotechnical treatments to ensure optimal development of cereals
Snow mould	use of certified seed, elimination of primary sources of infection, thorough incorporation of crop residues into the soil, and proper fertilization (maintaining the appropriate NPK ratio)
Brown rust	ploughing in of crop residues, destruction of intermediate hosts (barberry and mahonia), sowing of early-maturing varieties
Yellow rust	careful mixing of crop residues with the soil, destruction of volunteer plants, avoiding sowing spring cereals in the vicinity of winter cereals
Wheat leaf banded septoriosis	accurate covering of post-harvesting residues, destruction of volunteer plants
Septoria nodorum blotch	careful mixing of crop residues with the soil, use of certified seed

Ergot of cereals and grasses	sowing thoroughly cleaned grain, clearing the grass before formation of sclerotia, managing post-harvesting residues
Stem base rot blight	correct crop rotation
Seedling blight	crop rotation, optimal date of sowing; the correct depth and standard of sowing; good soil structure, balanced fertilisation

6.2.4. Chemical methods of disease vectors control

The possibility of chemical protection for wheat 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 wheat within the integrated production system (IP). Use instructions on the label should be read before application. The messages provided in the Online Pest Alerting System (www.agrofagi.com.pl) may be helpful.

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

6.3. REDUCING LOSSES CAUSED BY PESTS

6.3.1. The most important pests found in wheat cultivation

The most important pests occurring in cereal crops are aphids, frit flies, and wheat blossom midges. Pests can cause damage to both above-ground and underground parts. In integrated wheat production, it is mandatory to systematically monitor the field from emergence to the tillering once week for the presence of aphid-vectors of viruses, and from the beginning of the heading stage to ripening observations of once for two weeks (cereal leaf beetles, gall midges) (direct inspections of plants, yellow vessels, etc.). For several years now, also local, and in some years massive, appearances of other pests such as the Bishop's Mitre and tortoise bug, corn ground beetle, cereal chafer, leaf miners, frit fly, wheat-bulb fly, and soil pests – mainly cutworms, grubs, and wireworms have been observed. Cereals can also be damaged by snails and slugs, rodents, thrips, cephus pygmeus, chlorops ringens, nematodes, birds and game, and caterpillars of leafroller moths (Table 4).

Table 4. Current and projected importance of barley pests

Pest	Current	Forecast
Wireworms	+(+)	+++
Bishop's Mitre	++	+++
Bibionidae (march flies)	+	++

Ground beetle	++(+)	+++
Leaf miners	+(+)	++
Aphids	++(+)	+++
Cereal chafer	+	++
Chlorops ringens	+	++
Grubs	++	+++
Frit fly	++	+++
Gall midges	++	+++
Cutworms	++	+++
Leafhopper	+(+)	++
Cereal leaf beetle	++(+)	+++
Root flies	+(+)	++
Thrips	+(+)	++
Leafroller moths	+	++
Wheat stem-sawfly	+	++
Tortoise bug	++	+++
Rodents	(+)	+
Snails	+	++
Game and birds	+	+(+)

+ pest of minor importance, ++ important pest, +++ very important pest, ( ) pest of local importance

Details regarding the morphology and biology of pests, as well as the damage they cause, can be found, amongst other sources, in the 'Cereals Protection Alert Guide' at https://www.agrofagi.com.pl/plik,1152,poradnik-sygnalizatora-ochrony-zboz-pdf.pdf.

The main idea of integrated pest management is to use all available pest control methods while minimising the use of insecticides. It is a programme to manage pests in such a way as to keep their population below the threshold of economic harmfulness. In integrated cereal protection, non-chemical methods are used first, and only when the crop is threatened beyond the economic harmfulness threshold is insecticide protection applied. Prevention is very important, i.e. preventive action with all available non-chemical methods that reduce the number and development of pests.

6.3.2. Methods for monitoring pests in wheat cultivation

Monitoring for the presence of pests in a plantation is a very important part of integrated plant protection. Systematic, continuous observation makes it easier to assess the current situation in the field and to react quickly if necessary. On the basis of monitoring, decisions are taken on the relevance, timing and method of reducing the pest population. Monitoring is the basis of determining economic harmfulness thresholds, a key element of chemical protection. It is also worth monitoring the crop after the control treatment to determine its effectiveness or to decide whether to repeat the treatment. A number of methods have now been developed to monitor plantations, ranging from the simplest (direct inspection, yellow vessels, sticky boards, pheromone and bait traps) to those requiring the right tools and equipment (scooping, soil sieving, light traps, microscope).

Chemical treatment should be applied when previous methods have failed and the economic harmfulness threshold of a particular pest is exceeded. These values are indicative and depend, among other things, on climatic and agrotechnical conditions, fertilisation, variety, level of protection to date or the presence of natural enemies, so systematic observation of one's own plantation is essential. The primary and most effective method of monitoring for the appearance, severity or degree of plant damage is systematic crop monitoring. Depending on the pest species, this involves sifting the soil before sowing or observing the plants as they grow.

Details regarding harmfulness thresholds, as well as the timing and methods of pest monitoring, can be found, amongst other places, in the 'Cereals Protection Alert Guide'https://www.agrofagi.com.pl/plik,1152,poradnik-sygnalizatora-ochrony-zboz-pdf.pdf

6.3.3. Agrotechnical methods for the reduction of pests

One of the basic principles of integrated pest management for wheat is preventive measures, based primarily on agronomic practices (Table 5). Appropriate use of agricultural technology and the replenishment of any mineral nutrients shall improve the condition of plants in the early growth stages, when they are particularly vulnerable to attack from particular pest species. In addition, faster growth shall help to smother weeds which often provide a food base for some pests. Proper pre-sowing and post-sowing cultivation reduces the threat from pests, especially soil pests and those that overwinter in the soil. It is very important to implement crop rotation correctly. Many pests overwinter in the top layer of the soil or leftover plant residues. In the case of monocultures, pests after wintering have facilitated access to the food base. For this reason, spatial isolation is recommended, including from host plants of multivorous pests. Spatial isolation also helps make certain pests fly over longer distances. Appropriate measures to reduce the potential damage caused by individual pest species can also be taken at the seed sowing stage. The faster the initial vegetation stage of the plants, the more possibilities there are to anticipate the period of the greatest threat from the pests that are particularly dangerous to the emerging crops. The plant density is also important. Sowing too densely makes it easier for pests to spread, while sowing too sparsely favours weeds on which, for example, aphids thrive. The timing of the harvest is also very important — harvesting too late creates the risk of greater losses, especially in terms of yield quality. After the harvest, it is important to carry out a set of post-harvest cultivations aimed at thoroughly disintegrating plant residues (overwintering sites for certain pests), and reducing weed seeds, including perennial weeds. Post-harvest tillage should be followed by careful tillage to prepare the soil for sowing, which serves a phytosanitary purpose. A thick layer of soil covers the overwintering 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. At the same time, soil pests are mechanically destroyed.

Integrated plant protection consists in using all available methods that minimise the use of chemical plant protection products. Such a system of protection makes it possible to regulate pest numbers to a level below the economic harmfulness threshold, i.e. not endangering the crop, unlike all other methods that prevent the mass occurrence of pests by completely destroying them. The development of pro-ecological principles of plant protection against pests is particularly important, as any attempt to solve phytosanitary problems based only on a chemical method has become unreasonable and less effective. Pro-ecological principles and methods to protect most crops from harmful organisms (including pests) include, among other things, agrotechnical methods which are part of properly managed crop protection.

Table 5. Agrotechnical methods and means of protecting wheat against pests

Pest	**Methods and measures of protection**
Wireworms	proper crop rotation, careful mixing of post-harvest residues, discing, deep autumn ploughing, early sowing and increased sowing rate, weed control, spatial isolation from other cereals, root crops and brassicas
Bibionidae (march flies)	spatial isolation from other cereal plants, early seed sowing, increasing the standard of seed sowing
Bishop's Mitre	cultivation measures, spatial isolation from meadows and pastures, weed control
Ground beetle	spatial isolation from other cereal plants, increasing the standard of seed sowing, early seed sowing
Leaf miners	spatial isolation from other cereals, meadows and wasteland
Aphids	spatial isolation from other cereal plants, early seed sowing, balanced fertilisation, spraying of plants with selective insecticides, especially the edges of plantations
Cereal chafer	crop treatments, thorough mixing of crop residues with soil, spatial isolation from meadows and pastures
Nematodes	tillage operations, correct crop rotation cultivation, spatial isolation from other cereal crops
Chlorops ringens	spatial isolation from other cereal crops, late sowing of winter cereals, increasing the standard of seed sowing
Grubs	thorough mixing of crop residues with the soil, discing, weed control, increasing the seed rate
Frit fly	spatial isolation from meadows, pastures, grass seed plantations, control of weeds and cereal volunteer plants, delayed sowing of winter crops, accelerated sowing of spring crops

Gall midges	tillering operations, spatial isolation from other cereal crops, balanced fertilisation
Cutworms	spatial isolation from other cereals and crucifers and brassica vegetables, early sowing of grain, weed control, increasing the sowing rate of grain, increasing the fertilisation rate
Leafhopper	tillering operations, spatial isolation from other cereal crops, sowing of early varieties, increasing the fertilisation rate
Cereal leaf beetle	tillering operations, spatial isolation from other cereal plants, balanced fertilisation, spraying of plants, especially at the edge of the field
Snails	careful mixing of post-harvest residue with soil, discing, careful tillage, liming, destruction of weeds, spatial isolation from other cereals and crucifers and brassicas, early and deeper seed sowing, increasing the seed sowing rate
Root flies	spatial isolation from other cereal plants, early seed sowing, increasing the standard of seed sowing
Thrips	tillage, spatial isolation from other cereal plants, balanced fertilisation, plant spraying
Leafroller moths	tillering operations, spatial isolation from other cereal plants, increasing nitrogen fertilisation
Tortoise bug	cultivation measures, spatial isolation from meadows and pastures, weed control

6.3.4. Chemical methods of pest control

Plant protection products should be used in accordance with the current list of plant protection products recommended for wheat in integrated production (IP). Use instructions on the label should be read before application. The messages provided in the Online Pest Alerting System (www.agrofagi.com.pl) may be helpful.

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

7. BIOLOGICAL METHODS AND PROTECTION OF BENEFICIAL ENTOMOFAUNA IN INTEGRATED PRODUCTION OF WHEAT

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, disease pathogens and weeds in plant crops under field conditions and covered ground. It should be emphasised that biological agents do not eradicate pest populations in the same way as chemical pesticides; they only reduce their populations in the long term.

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. 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 into crops where they are absent or present in low numbers — the augmentative method.

Biological conservation method plays a huge role in the cultivation of wheat. It consists in human modification of the agricultural landscape in order to create suitable conditions for the operation of organisms useful in the environment. The number of beneficial organisms can be increased, among others, by sowing melliferous plants in the vicinity of crops, leaving natural dead furrows. These sites serve as habitats for those organisms that significantly reduce populations of various pests. The use of different cultivation techniques (e.g. non-ploughing) also promotes the development of soil-beneficial microorganisms such as insecticide and nematocide fungi. 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.

In wheat cultivation under natural field conditions, **ladybirds**, both adult insects and their larvae, are of great importance. Ladybirds feed primarily on aphids, but also true bugs, scale insects, mites, fly larvae, as well as young larval stages of butterflies. Representatives of **net-winged insects** (Neuroptera), whose larvae have sickle-like mandibles adapted to hollow out other insects, lead a predatory lifestyle. They feed on aphids, among others. Among the parasites that naturally limit the populations of aphids are the hymenoptera of the **aphididae** family. Aphids are also food for predatory flies (Diptera), mainly belonging to **hoverflies** family (Syrphidae). In natural conditions, the flies of the family **Tachinidae** play an enormous role in reducing the population of many harmful insects. Of **the heteropterans**, the predatory species represented by the capsid bug (Miridae), minute pirate bug (Anthocoridae), and shield bug (Pentatomidae) families are important.

The importance of beneficial **Carabidae** beetles is increasing in integrated plant protection. They occur in large numbers in all agricultural environments, including wheat crops. Due to their large size, high motility and great voraciousness, they are among the most effective beneficial insects, significantly limiting the number of plant pests. Under natural conditions, beneficial insects also include **earwigs** which reduce the number of aphid colonies. Also, beetles from the family of **rove** beetles (Staphylinidae) are among insects that control the number of pests.

Spiders have an underestimated importance in nature. The role of spiders is extremely important, as they destroy pests during the initial period, even before other natural enemies of pests appear. Often more insects are caught in the spider's web than the predator is able to eat. Unfortunately, spiders are multivorous, so beneficial insects also fall victim to them. **Insecticidal bacteria**, such as *Bacillus thuringiensis*, are also important in the soil environment. Under favourable conditions (high humidity and temperatures above 20 °C), insecticidal fungi belonging to the **insectivores** (Entomophthoraceae) play a major role. These fungi can cause epizootic diseases, i.e. mass extinction of aphid colonies.

In the cultivation of winter and spring wheat, biofungicides based on the parasitic fungi *and Pythium oligandrum* may be used to control the causative agents of fusarium blight of ears, provided that such products have been registered. The parasitic fungus *P. oligandrum* protects the root and the zones above the ground from fungal diseases. Its activity is based on destroying fungal hyphae. It is a parasite of some plant disease pathogens. Its function is to decompose pathogenic fungal hyphae by enzymatic decomposition, while stimulating the immune mechanisms of the protected plant by introducing phytohormones as well as phosphorus and sugars. The fungus works best on soils with a pH of 5.5-7.5, with a soil temperature of 12 to 25 °C. Treatments are best carried out in the morning or evening, and strong sunlight should be avoided. It is necessary to remember not to use chemical fungicides, because they negatively affect the action of the fungus. *P. oligandrum* not only has a protective effect, but also provides additional nutrients to the plant through the roots. Thanks to its presence in the soil, in the root zone, plants grow stronger and healthier and their flowering is more successful. The product is environmentally safe and does not require a grace period.

Predatory birds living near plantations are effective in controlling small mammals (rodents, hares). To allow observation, resting poles with a minimum height of 3 m should be placed along the plantation, at least 1 per 5 hectares.

Protection of bees and other pollinators

Pollinators are an extremely useful group of organisms, with bees being the most important among them. The best-known pollinators here are the honeybee (Apis mellifera) and bumblebees (Bombus spp.). In order to create the best possible habitat for pollinators, the edges of agricultural fields are sown with melliferous plants. Many pieces of legislation provide the basis for the obligation not only to protect beneficial organisms, but also to create favourable conditions for their development. Within the framework of integrated plant protection, when carrying out chemical plant protection treatments, consideration should be given to selecting plant protection products in a way that minimises the negative impact of plant protection treatments on non-target organisms, in particular pollinating insects and natural enemies of harmful organisms.

Therefore, in order to protect beneficial entomofauna, it is essential to know the description and development stages of the beneficial species in order to assess their presence, the need to treat them with a chemical agent or not, and the correct choice of agent to be used.

Intensive research is being conducted the aim of which is to get to know the role of beneficial species and the possibilities of their more effective use. The latter can already be obtained by undertaking many activities which include:

- rational use of chemical plant protection products and basing decisions on the real risk to the wheat crop from pests, assessed on an ongoing basis. One should consider abandoning treatments if pests do not occur in large numbers and are accompanied by the occurrence of beneficial species. In this group of activities, the limitation of the treatment area to treatments on the edges and in patches should be considered if the pest does not occur on the whole plantation;
- 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;
- dose reduction and adjuvant addition based on the results of analyses;
- constant awareness that protecting natural enemies of oilseed wheat pests also protects other beneficial species present in the field;
- leaving dead furrow, mid-field refuges for many species of beneficial insects;
- reading carefully the content of the label accompanying each plant protection product and observing the information contained therein.

Very efficient pollinators include insects that live in the wild in agrocenoses. In order to ensure their development, 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 ha.

Protection of biodiversity and beneficial species

Winter and spring wheat fields are a home to a wide range of insect species some of which are treated as pests. i.e. species that cause losses that outweigh the cost of controlling them. Many species neutral to cultivation occur at low density or are present there accidentally. The fields are inhabited by a large group of predators and parasites — enemies of natural pests. From the point of view of plant protection and the biological method, it is this last group, called beneficial entomofauna, that is of fundamental importance in regulating the occurrence and number of insects, including harmful ones, and should be a very important element in integrated crop protection against pests.

A very important element in the evaluation of a biological method is the consideration of the role of environmental resistance, i.e. the contribution of naturally occurring natural enemies of harmful organisms in reducing their occurrence. In the dissemination of integrated protection, the producer's preparation and knowledge of the environment of wheat fields and the processes taking place in them shall be the most important thing, and it is this knowledge that should also be the stimulus for interest and the introduction of a biological method on the farm.

Natural enemies are most often not able to continuously reduce the number of pests to levels below economic harmfulness thresholds. However, it should be remembered that integrated production, whose basic element is integrated pest management, requires producers to provide reasonable protection based on the greatest possible use of the useful activity of parasites and predators.

8. APPROPRIATE SELECTION OF TECHNIQUES OF APPLICATION OF PLANT PROTECTION PRODUCTS

Storage of plant protection products

Plant protection products must 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 by or earmarked for animal feeding,
- are inaccessible to children,
- there is no risk of:
  - contamination of surface and groundwater within the meaning of the water law,
  - soil contamination due to leakage or seepage of plant protection products into the soil profile,
  - penetration into sewage systems, excluding separate drain-free sewage systems equipped with a leak-proof sewage tank or equipment for their neutralisation.

The labelling of plant protection products contains information on the principles of safe storage.

In accordance with the good practice principles, plant protection products should be stored in separate rooms (outside residential and livestock buildings). These rooms should be clearly marked (e.g.: ‘plant protection products’) and protected 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 on the label and in the safety data sheet of the plant protection product. The basic protective clothing gear 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 work organisation and available technical measures should be used at each stage of the handling 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 in good technical condition, ensure reliable operation and guarantee the safe use of plant protection products, liquid fertilisers or other agrochemicals. The sprayer must have undergone a technical inspection (with up-to-date certification) and be properly calibrated. The good technical condition of the equipment must be 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 must be carried out no later than five years after its acquisition and subsequent tests must be carried out at intervals of no more than three years.

Equipment used for plant protection treatments must be safe for humans and the environment. In addition, it should guarantee the full effectiveness of protective treatments by ensuring proper operation that allows accurate dosing and even distribution of 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 adjustments of the sprayer make it possible to choose the optimal parameters of the treatment. In accordance with good plant protection practice in terms of the adjustment (calibration) process of the sprayer, the type and dimension of the sprayers and the working pressure should be determined so that they ensure the application of the intended 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 sprayed 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 of 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 plant protection, selective measures with low risk to pollinators and beneficial organisms should be chosen.

Treatments with plant protection products should be planned in a way that ensures acceptable efficacy with the minimum quantity of plant protection product necessary, taking local conditions into account.

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 the soil and air, type of soil as well as the content of organic matter in the soil.

The decision to use a plant protection product at a dose lower than 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 individual treatments,**
- **maximum number of uses of the product during the season,**
- **maximum dose of the plant protection product.**

Selection of spray liquid volume

In integrated crop production, the volume of spray liquid (l/ha) should be selected based on available catalogues, training materials and handbooks or other thematic papers. 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.

Surface agents require very good coverage of sprayed plants and generally require the use of more spray liquid 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 suitable treatment equipment (e.g. sprayers with auxiliary air stream [AAS]), the dose can be possibly reduced to 50–100 l/ha which should guarantee sufficient coverage of the treated 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 concerning their use for the protection of agricultural crops are useful in the selection of suitable sprays for individual 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 spray liquid

The intended volume of the liquid must be prepared immediately before the procedure to avoid undesirable physicochemical reactions. The sprayer agitator must be switched on at all times to protect the mixture from precipitation 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 must be filled on an impermeable and hardened surface (e.g. concrete slab), in a place where it is possible to prevent the spreading of spilled or leaked plant protection products;
- the measured quantity of crop protection product should be poured into the partially filled tank with the agitator switched on or in accordance with the instructions for use of the sprayer;
- empty plant protection product packaging must be rinsed three times, the contents poured into the spray tank, and the packaging preferably returned to the seller;
- if possible, it is best to fill the sprayer on a special station 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 with the contaminated material should be stored in plant protection product storage until safely disposed of.

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), followed by water to the desired volume of the sprayer tank.

In multiple-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 ingredients, replenish the tank with water to the required volume.

Do not use water at a low temperature (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 intended to be covered by the treatment, and may cause unintended poisoning of many beneficial species of entomofauna.

Table 6. 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 details are included in the label texts. For most preparations, optimal effectiveness is achieved at a temperature range 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 (temperature and wind speed) or lower (air humidity) limit values, drift-limiting spray nozzles (e.g. low drift or ejector nozzles) and lower recommended operating pressures should be used for spraying operations.

Table 6. Limit and optimal meteorological conditions for plant protection treatments

Parameter	Limit values (extreme)	Optimal values (most favourable)
Temperatures	1–25 °C during treatment	12–20 °C during treatment
	up to 25 °C on the day after	20 °C on the day after
	not less than 1 °C the next night	not less than 1 °C the next 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 the treatment	
Wind speed	0.0–4.0 m/s	0.5–1.5 m/s

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

- 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 with the labelling of plant protection products in the first place. Distances (buffer zones) from specific sites and facilities for the use of plant protection products are greater on many labels than those indicated above.

The spraying procedure is performed at a constant movement speed and working pressure, set during sprayer adjustment. Successive runs over the field should be made very precisely to avoid strips being left unsprayed 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 drains. The sprayer must 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.

Procedure for rinsing the tank and liquid system

- use the least necessary amount of water for rinsing (2–10 % of the volume of the tank or an amount that dilutes liquid remaining in the tank up to 10 times); it is recommended to rinse the liquid system with a small portion of water three times.
- 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, use the residues according to the recommendations on the management of liquid residues,
- the residual liquid drained from the sprayer must 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 earmarked for that purpose.

External washing of the sprayer

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 washing of the sprayer should be carried out at a location that allows the washings to be directed into a closed collection system for contaminated residues or into a neutralisation/bioremediation system (e.g. Biobed, Phytobac, Vertibac station); if this is not possible, the sprayer should preferably be washed 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.

Recording 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 was carried out,
- reasons for the treatment with a plant protection product.

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

9. HYGIENE AND HEALTH RULES

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

A. Personal hygiene of workers

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

a) not be infected with or suffer from food-borne diseases;
b) maintain personal cleanliness, obey the rules of hygiene, and in particular wash hands frequently during work;
c) wear clean clothes and, where necessary, protective clothing;
d) cover wounds and skin abrasions 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 undergone hygiene training.

B. Hygiene requirements for crops prepared for sale

The plant producer must take appropriate measures to ensure that:

a) clean or consumption-class water is used to wash the crops as necessary;
b) during and after harvesting the crops are protected against physical, chemical, and biological pollution.

C. Integrated plant production hygiene requirements for packaging, means of transport and places for the preparation of crops for sale

Under integrated plant production, the producer takes the necessary actions to ensure that:

a) cleanliness of rooms (and equipment), means of transport and packaging is maintained;

b) order is maintained on driveways and around buildings where merchandise is stored and prepared for trade;
c) farmed and domestic animals have no access to the rooms, vehicles or packaging;
d) harmful organisms (pests and organisms dangerous for humans) are eliminated, which may lead to contamination or pose a threat to human health, e.g. mycotoxins;
e) hazardous waste and substances are not stored together with crops prepared for sale.

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

In integrated wheat production, the first date when wheat may be harvested is the full maturity stage when which the grains are already hard, contain less than 17 % water, and are difficult to divide with a nail. However, grains with humidity above 14.5 % need to be dried. Therefore, the best time to harvest wheat is at the over-ripe stage, when the plants die and dry out. Grains are very hard, cannot be dented by thumbnail, and the water content in them drops below 14 %. However, it should be borne in mind that with too low grain humidity (approx. 12 % and less) cause the greatest damage to them. Therefore, winter and spring wheat grains grown under the IP system must be harvested when their moisture content is between 12 % and 14 %. Where justified, harvesting may be carried out at higher or lower moisture content, bearing in mind the need to handle the grain appropriately, e.g. by allowing it to dry further at higher moisture content or by harvesting in the evening when moisture levels are lower.

An important principle of rational harvesting is to carry it out in the shortest possible time. In the first place, especially in humid weather conditions, it is necessary to harvest seed intended for seed and for consumption purposes due to the risk of growing or developing fungi.

Preparation of the field for harvesting

The proper course of harvest is influenced by several factors, in particular the good condition of machinery and equipment used for harvesting, transport, storage and storage of grain, proper preparation of access roads and field surfaces as well as organisation of work during the whole harvesting technology.

An important step in the cultivation of cereals is the preparation of the surface of the field for harvesting which should be remembered already before sowing and well level the surface of the field, and remove stones. The presence of stones contributes to an increased number of technical defects, especially when harvesting lodged and weed-infested cereals, requiring low cutting. It is also necessary to check and clean the edges of the fields and mark obstacles that are difficult to notice by the operator of the harvester, i.e. wetlands, concrete geodetic posts, drainage wells, etc.

Maturation within a single part of a field may be uneven, making it difficult to decide when to start harvesting. Too early, the harvesting aggravates the conditions of its threshing and cleaning, reduces harvesting efficiency, increases fuel consumption, and can lead to greater expenditure on grain maintenance. On the other hand, delayed harvesting increases grain losses caused by the work of the harvest team.

Water content in the vegetable mass and the humidity of the air during harvesting has a significant impact on the course of work of the harvester. Increased straw moisture, a feature of some wheat varieties, often contributes to clogging the working elements of the harvesting unit, while too dry straw may undergo greater fragmentation in the threshing assembly which contributes to overloading the shakers and sieves of the cleaning unit, and ultimately to increased grain losses.

Continuous precipitation of low intensity for two hours causes a 1 % increase in grain moisture. In contrast, the decrease in grain moisture caused by rainfall during favourable weather is slower.

With air humidity not exceeding 75 % and a temperature of around 18 °C, the capacity of the harvester is used only in 50–60 %. Increase in the humidity of ambient air above 75–80 %, which often occurs even in good and stabilised weather in the morning and evening, contributes to the moisture of the collected mass, and this increases the incidence of threshing syndrome. Therefore, the efficiency of harvesters during harvesting work in the afternoon is higher by 50–100 % than morning and evening. The early morning hours, when the combine harvester operates at a lower working speed, should be used for mowing the field edges and dividing the fields into plots.

Work organisation during harvesting

The harvester should be fully technically operational before starting the harvesting. In particular, the condition of the threshing unit should be checked. Worn out flails and tick lead to a decrease in the quality of the hammer. In order to reduce losses and high grain contamination, appropriate adjustments need to be made to the harvester: the slot size of the threshing unit, the drum speed, the slot size of the flap sieves, and the fan speed.

Theoretically, the settings of the harvester for work are provided by the user manual, and in the case of state-of-the-art machinery, information on how to set up individual operating units also is included in on-board computers. In some machines, such adjustments may be performed automatically. Notwithstanding this, the parameters specified by the producer should only be considered as the starting point for the detailed adjustments set by the machine operator. In particular, it should be taken into account that the amount of damage and grain loss during threshing is also determined by the choice of threshing drum speed and the adjustment of the releasing and cleaning system.

When organising harvester operations, the method of the combine’s movement should be selected. A bed-type movement of the harvester, parallel to the direction of sowing, should be aimed for, to allow a higher working speed to be obtained as the harvester does not have to overcome lateral bumps in the field. Circular motion is recommended in small fields of irregular shapes where it is impossible to move through using the bed-type movement. This mode of movement reduces the daily yield of the harvester by an average of 1 to 1.5 ha as a result of long-term relapses. This movement also hinders the operation of straw harvesting machines. In the case of the harvesting of tilted and lodged cereals, the direction of harvester movement shall be adjusted to the tilt (lodges).

With the bed-type movement of the harvester, large fields should be divided into beds. The width of beds should meet the aim of minimising the time lost on idle rides when turning back, while the width of the headland should ensure the possibility of easy turning back. The width of the first strip should be ten times the size of the working width of the harvester, and the subsequent strips 20 times.

Organisation of the work during grain harvesting at collecting it from the harvester and transporting it to the storage area has a significant influence on the actual performance of the harvester. The number and type of means of transport should ensure collection of grain from the harvester at its maximum efficiency which usually occurs in the afternoon. The general rules for the organisation of work in harvester cereal harvesting technology assume that the efficiency of the means of transport is at least equal to that of the harvester operating. Thus, the harvester can work without waiting for the means of transport.

The most commonly used ways of unloading grain from a harvester tank are: unloading to trailers brought to the harvester at a standstill, and unloading during operation of the harvester to trailers moving next to the harvester. Unloading of the tank during the operation of the harvester is more efficient, but requires high-skilled machine operators. The disadvantage of this method of grain harvesting is that it is difficult to use the full capacity of cargo boxes. Unloading of grain to trailers located on one or both headlands is the least efficient. In the case of large-scale farms, it is recommended to transport grain from the harvester to the container trucks or lorries parked on the headland by means of special handling trailers.

Cargo boxes must be properly sealed and prepared for grain transport. Inadequate preparation of the trailer, e.g. inaccurately closing sides or gaps in side/floor contact point, leads to large grain losses.

Handling grains after harvesting

The grain delivered to the storage place must be efficiently unloaded and then subjected to post-harvest treatment. These activities require adequate storage facilities and equipment with technical means. The grain storage shall perform the following technological functions: receiving the grain, pre-cleaning, maintenance: drying, cooling, ventilation, storage (storage) with control of storage conditions, accurate cleaning, retrieval, possibly dressing, and dispatch.

The capacity of the grain receiving process line should provide for a reserve in relation to the maximum operating capacity of harvesters in order to overcome any build-ups in the supply. The reserve should be about 20 % relative to the maximum operating efficiency of the harvester. The basic objective of the presented requirements is to reduce the time of stopping trailers at the warehouse to the necessary minimum needed for unloading.

Grain purity is important for longer storage. Harvester operation should be adjusted in such a way that pre-cleaning eliminates a significant part of the impurities, including weed seeds. All organic pollutants (seeds, parts of weeds, broken grains, green parts of plants) have a higher moisture content than the harvested grain.

Life processes of respiration and oxidation take place in the grains. After the grain has reached full maturity, they are still quite intense. Harvesting does not interrupt these processes. Post-harvest ripening of the grain should be monitored by measuring the temperature in the grain heap and ventilating it if necessary.

Wheat grains are stored in flat storage facilities and silos, while long-term grain storage usually taking place in silos. The main determinants of safe grain storage include: grain moisture content, storage temperature, contamination levels, air contact and degree of damage to the grain cover. During storage, microclimate conditions must be controlled so that the grains are not exposed to moisture. In grain silos and storage facilities, control is also necessary to detect the possible occurrence of pests.

Currently, there are many producers of cereal seed silos on the market. Important factors include: silo bottom design, unloading system, ventilation method, proper fan selection, and measurement system recording changes in the temperature of stored seeds. The correct combination of technical storage factors with the physical characteristics of the grain allows the long-term storage of wheat.

Grain from crops grown under the integrated production system must not be mixed with grain harvested from fields excluded from IP.

11. DEVELOPMENT STAGES OF WHEAT ON THE BBCH SCALE

In the development of common wheat (*Triticum aestivum L. subsp. Aestivum*) there are all 10 major developmental stages: 0 — Germination, 1 — Leaf development, 2 — Tillering, 3 — Stem elongation, 4 — Swelling of the leaf sheath of the flag leaf, 5 — Heading, 6 — Flowering, 7 — Kernel development, 8 — Ripening, 9 — Senescence. The intervals between stages, the number of leaves, and the height of the plants at each stage depend on individual variety characteristics and other agro-ecological factors. The first tillering stage usually occurs when the plant already has 3 or 4 leaves. When stem elongation begins, the plant completes tillering, the stem straightens and the leaf sheaths thicken. Tillering is already completed before the stem-elongation stage. For winter cereals, stem elongation marks the transition of the plant from the vegetative to the generative stage as evidenced by the microscopic structure of the ear the beginnings of which are already formed during the formation of the 4th, 5th, or 6th leaf. At this stage of development, the number of spikelets per ear and thus the final size of the ear is already determined. In the longitudinal section of the main stem, a small spikelet is visible which is gradually pushed up towards the top of the stem as more internodes appear. The flag leaf usually appears when there are at least 3 nodes above the soil surface. During the BBCH 31–33 development stages, the highest growth dynamics of the plant are observed. Care should be taken not to confuse the first proper node with the tillering node. The appearance of the flag leaf buds marks the end of stem elongation as the plant enters the heading stage. An inflorescence and eventually an ear is visible in the flag leaf sheath.

CODE DESCRIPTION

Principal growth stage 0: Germination

00 Dry seed (caryopsis)
01 Beginning of seed imbibition, soft kernel of a typical size
03 Seed imbibition complete, swollen kernel
05 Radicle has emerged from caryopsis
06 Radicle elongated, root hairs and/or side roots visible
07 Leaf shed (coleoptile) emerged from the kernel
09 Coleoptile breaks through to the soil surface (soil cracking)

Principal growth stage 1: Leaf development[1],[2],[3]

10 The first leaf emerges from the leaf sheath (Coleoptile) (pinning)
11 1st leaf unfolded
12 2nd leaf unfolded
13 3rd leaf unfolded
14 4th leaf unfolded
15 5th leaf unfolded
1. These stages continue until…
19 9 or more leaves unfolded

Principal growth stage 2: Tillering

20 No tillers
21 Beginning of the tillering stage: 1st tiller visible
22 2 tillers detectable
23 3 tillers detectable
2. Stages continue until…
29 End of the tillering stage. Maximum no. of tillers detectable

Principal growth stage 3: Stem elongation

30 Beginning of stem elongation: pseudostem and tillers erect, first internode begins to elongate, top of inflorescence at least 1 cm above tillering node
31 Node 1 at least 1 cm above tillering node
32 Node 2 at least 2 cm above node 1
33 Node 3 at least 2 cm above node 2
3. Stages continue until…
37 Flag leaf just visible, still rolled
39 Flag leaf stage: flag leaf fully unrolled, ligule just visible

Principal growth stage 4: Swelling of the leaf sheath of the flag leaf (development of ears in the leaf sheath)

41 Beginning of thickening (swelling) of the flag leaf sheath, early stage of ear development
43 Mid boot stage: flag leaf sheath just visibly swollen
45 Final stage of swelling of the flag leaf sheath, late stage of ear development
47 Flag leaf sheath opening
49 First awns visible

Principal growth stage 5: Heading

51 The beginning of heading: tip of inflorescence emerges from the sheath, first spikelet just visible
52 20 % of the inflorescence emerged
53 30 % of the inflorescence emerged
54 40 % of the inflorescence emerged
55 50 % of the inflorescence emerged
56 60 % of the inflorescence emerged
57 70 % of the inflorescence emerged
58 80 % of the inflorescence emerged
59 End of heading, all spikelets emerge from the sheath, the ear is fully visible

Principal growth stage 6: Flowering

61 Beginning of the flowering stage: first anthers visible
65 Full flowering: 50 % of anthers mature
69 End of flowering: all the spikelets have completed flowering but some dehydrated anthers may remain

Principal growth stage 7: Kernel development

71 Water maturity: the first watery grains have reached half their typical size
73 Early milk
75 Medium milk: grain content milky, grains reached final size, still green
77 Late milk

Principal growth stage 8: Ripening

83 Beginning of waxy maturity of the kernels
85 Soft waxy maturity, grains easily smeared between the fingers
87 Hard waxy maturity, grains easily broken with a fingernail
89 Full maturity, hard grains, difficult to split with a fingernail

Principal growth stage 9: Senescence

92 Over-ripe: very hard grains, cannot be dented by a fingernail
93 Grains loose in the ear, may fall off
97 Plant dead and collapsing
99 Harvested product, resting period

[1] A leaf is developed when its ligule or the tip of the next leaf is clearly visible

[2] Tillering or elongation of the stem may occur earlier than in Phase 13, then the description is continued in phase 21

[3] If the stem elongation phase begins before the end of the tillering phase then the description is continued in phase 30.

12. LIST OF MANDATORY ACTIVITIES AND TREATMENTS IN THE INTEGRATED PRODUCTION OF WINTER WHEAT AND SPRING WHEAT

Mandatory requirements (compatibility of 100 %, i.e. 13 points)			
No.	**Control points**	**YES/NO**	**Comment**
1.	The use of an appropriate crop rotation (with very good or good precursor crops) as recommended in the methodology (**Chapter 2.3**)	/	
2.	Selection of varieties according to the RCFCT guidelines (**Chapter 3**)	/	
3.	Performing agrotechnical treatments to reduce weed infestation before sowing (**Chapter 4.1**)	/	
4.	Application of certified and dressed seed and sow at the appropriate standard and date (**Chapter 4.2**)	/	
5.	Analysing soil pH and the content of the main nutrients (NPK and S) according to the cycles indicated in the methodology confirmed by documents (**Chapter 5**)	/	
6.	Use at appropriate dates and doses of macro and micronutrient fertilisation according to soil type and pH after a nutrient balance has been carried out (**Chapter 5**)	/	
7.	Use of agrotechnical methods as the first step in weed control and, in the case of chemical control, the correct application of herbicide at the right dose, taking into account the level of susceptibility of the weeds determined for individual weeds or their groupings (**Chapter 6.1)**	/	
8.	Systematically monitoring the field in the stage of tillering/stem elongation, flag leaf, heading in order to assess the occurrence of diseases (powdery mildew and of cereals and grass, leaf septorioses, brown rust, brown leaf spots, yellow rust) with particular emphasis on fusarium blight of ears after heading (**Chapter 6.2**)	/	
9.	Systematic monitoring of the field from the emergence to the tillering: once per week for occurrence of aphid vectors of viruses, and observations once every two weeks from the beginning of the heading stage to maturation (cereal leaf beetles, gall midges) (direct inspection of plants, yellow vessels, etc.) (**see Chapter 6.3)**	/	
10.	Performance of at least one pest control treatment with a biological control product (**Chapter 7**)	/	
11.	Creating suitable conditions for the presence of birds of prey, i.e. setting up resting poles at a minimum number of 1 per 5 ha and, in the case of larger plantations, several poles (**Chapter 7)**	/	
12.	Setting up ‘houses’ for mason bees or bumblebee mounds, or other facilities for pollinating insects in the number of at least 1 per 5 ha (**Chapter 7).**	/	
13.	Harvest at the right time (correct grain moisture) (**Chapter 10**)	/	

Note:

The fulfilment of all the requirements in the list of mandatory actions and treatments under the integrated production scheme must be documented in the integrated plant production Notebook.

13. CHECKLIST FOR AGRICULTURAL CROPS

Basic requirements (100 % compliance, i.e. 27 points)			
No.	**Control points**	**YES/NO**	**Comment**
1.	Does the producer produce and protect the crops according to detailed methodologies approved by the Main Inspector?	❑/❑	
2.	Does the producer have up-to-date IP training attested by a certificate?	❑/❑	
3.	Does the producer only use plant protection products listed as approved for IP and for use on the specific crop?	❑/❑	
4.	Are all the documents specified in the methodology and logbook (e.g. test results, proof of purchase) present on the farm and properly stored?	❑/❑	
5.	Is the IP Notebook kept correctly and up to date?	❑/❑	
6.	Does the producer handle empty plant protection product containers and expired products in line with the provisions in force?	❑/❑	
7.	Is chemical protection of crops replaced by alternative methods wherever justified?	❑/❑	
8.	Are treatments performed with the use of plant protection products carried out exclusively by persons who hold, for the duration of treatment, a valid certificate of completion of training in the use of plant protection products or advisory on plant protection products, or integrated crop production, or another document confirming certification to apply plant protection measures?	❑/❑	
9.	Is every application of a plant protection product recorded in the IP logbook, taking into account the severity of pest infestation in accordance with the methodology and the need to carry out the treatment?	❑/❑	
10.	Were plant protection treatments carried out under appropriate conditions (optimal temperature, permissible wind speed)?	❑/❑	
11.	Is the rotation of the active substances of plant protection products used in treatments?	❑/❑	
12.	Does the producer limit the number of treatments and the amount of crop protection products used to a necessary	❑/❑	

Basic requirements (100 % compliance, i.e. 27 points)			
No.	**Control points**	**YES/NO**	**Comment**
	minimum?		
13.	Does the producer have measuring devices to precisely determine the quantity of the measured plant protection product?	❑/❑	
14.	Does the producer comply with the instructions on the label regarding the preparation of the working solution, the disposal of any remaining solution and the cleaning of the equipment?	❑/❑	
15.	Does the producer comply with the label's instructions regarding safety precautions for users, staff and bystanders?	❑/❑	
16.	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?	❑/❑	
17.	Are prevention and withdrawal periods observed?	❑/❑	
18.	Are the application rates and the maximum number of treatments during the growing season, as specified on the plant protection product label, being exceeded (if the IP methodology imposes stricter requirements than the label, the provisions of the IP methodology shall be complied with)?	❑/❑	
19.	Were the sprayers listed in the IP logbook in working order and did they have valid technical inspections at the time the plant protection products were applied?	❑/❑	
20.	Does the producer carry out systematic calibration of the sprayer(s)?	❑/❑	
21.	Does the producer have a space for filling and cleaning the sprayers?	❑/❑	
22.	Are plant protection products stored in a labelled, locked room in a manner that prevents environmental contamination and access by unauthorized persons?	❑/❑	
23.	Are all plant protection products stored exclusively in their original packaging and in such a way as to prevent them from coming into contact with food, drink or animal feed?	❑/❑	
24.	Does the producer apply fertilisation on the basis of the actual nutrient requirements of the crops, determined in particular on the basis of soil or crop analyses?	❑/❑	

Basic requirements (100 % compliance, i.e. 27 points)			
No.	**Control points**	**YES/NO**	**Comment**
25.	Is each fertilisation recorded in the IP Notebook taking into account the application form, type, date, amount, place and area?	❑/❑	
26.	Did the producer perform all the necessary agrotechnical procedures in accordance with the IP methodology?	❑/❑	
27.	Does the IP producer observe hygienic and sanitary principles, especially those specified in the IP methodology?	❑/❑	
	Total points		

Additional requirements for field agricultural crops (minimum compliance 50 %, i.e. 5 points)			
No.	**Control points**	**YES/NO**	**Comment**
1.	Is each box marked according to the entry in the IP notebook?	❑/❑	
2.	Is the recommended catch crop used in cultivation?	❑/❑	
3.	Are fertiliser application machines maintained in good working order?	❑/❑	
4.	Do fertiliser application machines allow for accurate dose adjustment?	❑/❑	
5.	Are fertilisers stored in a separate and specially designated room in a manner that ensures protection of the environment against contamination?	❑/❑	
6.	Does the producer protect empty PPP packaging against unauthorised access?	❑/❑	
7.	Does the producer have a properly equipped space for collecting waste and rejected crops?	❑/❑	
8.	Are there first-aid kits in the vicinity of workplaces (e.g. storage rooms, utility rooms, cold storage)?	❑/❑	
9.	Does the producer know how to proceed in the event of a spill or the scattering of plant protection products?	❑/❑	
10.	Does the producer use consultancy services?	❑/❑	
	Total points		

Recommendations (min. implementation 20 %, i.e. 2 points)			
No.	**Control points**	**YES/NO**	**Comment**
1.	Are soil maps drawn up for the holding?	❑/❑	
2.	Are non-organic fertilisers stored in a clean and dry room?	❑/❑	
3.	Has a chemical analysis of organic fertilisers been carried out in terms of nutrient content?	❑/❑	
4.	Is there an irrigation system on the farm that ensures optimal water consumption?	❑/❑	
5.	Is the water used for irrigation tested in a laboratory for microbiological and chemical contamination?	❑/❑	
6.	Does the lighting in the room where the plant protection products are stored make it possible to read the information on the packaging of the plant protection products?	❑/❑	
7.	Are there instructions on how to deal with spills or scattering of plant protection products on the farm, and are there tools to counteract such a threat?	❑/❑	
8.	Does the producer improve their knowledge at Integrated Plant Production meetings, courses or conferences?	❑/❑	
9.	Does the producer ensure, in the crop environment, conditions conducive to the survival of natural enemies of harmful organisms (other than those required in the list of mandatory activities and treatments)?	❑/❑	
	Total points		

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