MAIN INSPECTORATE OF PLANT HEALTH AND SEED INSPECTION

PIORIN

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Integrated production methodology of sweetcorn

(first edition)

Approved
pursuant to Article 57(2)(2) of the Act of 8 March 2013 on plant protection products
(i.e. Journal of Laws of 2023 item 340)

by

the Main Inspector of Plant Health and Seed Inspection

Warsaw, March 2024

INTEGRATED PRODUCTION
OFFICIALLY CONTROLLED

Approved by

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ISBN 978-83-64655-90-6

Methodology developed as part of task 1.5.
"Development of Integrated Plant Production Methodologies"
financed by the Ministry of Agriculture and Rural Development

1. INTRODUCTION

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

2. INTEGRATED PRODUCTION (IP) LEGISLATION AND IP CERTIFICATION RULES

2.1. Integrated plant protection as the foundation of integrated production

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

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

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

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

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

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

It is the duty of every user to read the label and adhere to its provisions before applying the plant protection product.

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

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

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

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

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

2.2. Integrated plant production in legislation

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

2.3. Principles of certification

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

The intention to use integrated plant production is notified by the plant producer every year to the certifying body, **no later than 30 days before sowing or planting, or – in the case of perennial crops – by 1 March each year.**

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

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

- completion of IP training;
- compliance with the production methods approved by the Main Inspector of Plant Health and Seed Inspection;
- fertilisation;
- documentation;
- following hygiene and health principles;
- sampling and control of maximum residue limits for plant protection products and levels of nitrates, nitrites and heavy metals in plants and plant products.

The maximum permitted plant protection product residue content and nitrate, nitrite and heavy metal levels in plants are tested in the plants or plant products of no less than 20 % of the growers listed in the grower register held by the certification body, starting with any growers suspected of not following integrated plant production principles. The tests shall be carried out in accredited laboratories.

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

- has completed training in integrated plant production and holds a certificate of completion of that training, subject to Article 64(4), (5), (7) and (8) of the Plant Protection Products Act;
- conducts production and protection of plants according to detailed methodologies approved by the Main Inspector and made available on the website managed by the Main Inspectorate of Plant Health and Seed Inspection;
- uses fertilisation based on the actual demand of plants for nutrients, determined in particular on the basis of soil or plant analyses;
- documents the correct conduct of activities related to integrated plant production;

- complies with hygiene and sanitary rules with respect to the production of plants, in particular those specified in the methodologies;
- in plant and plant product samples collected for testing, no maximum permissible residues of plant protection products and levels of nitrates, nitrites and heavy metals have been exceeded;
- plant protection requirements relating to harmful organisms, in particular those specified in the methodologies, have been met.

Integrated pest management certificates are issued for the period necessary for the plant product to be disposed of, but no longer, however, than 12 months.
Growers who have been granted a certificate attesting that they follow integrated plant production principles may use the Integrated Plant Production mark to distinguish the plants for which the certificate has been issued. A sample mark is provided by the Main Inspector on the website of the Main Inspectorate of Plant Health and Seed Inspection.

3. CLIMATE AND SOIL REQUIREMENTS, AND SITE SELECTION

3.1. Climate

Sweetcorn (*UAE mays* SSP. *saccharata*) is a plant of a warm and sufficiently humid climate. In Poland, it is classified as a minor vegetable crop with a sowing area of about 13 000 hectares in 2023. It requires a lot of sunshine, and as a short-day plant shows a fairly weak photoperiodic reaction. It belongs to the latest sown spring plants in our country. The climatic conditions of Poland are sufficiently beneficial for this plant and allow it to be cultivated in almost the whole country, except in the foothills and mountain areas. Two factors have the greatest impact on the growth, development and yield of sweetcorn, namely temperature and rainfall. A temperature of 8-10^{o} C is required for equal and rapid sprouting. Optimal growth temperature from sowing to flowering is from 21 to 27^{o} C. Sweetcorn stops growing at temperatures below 4^{o} C. spring chills, especially frosts occurring during emergence and at the beginning of sweetcorn vegetation, inhibit plant growth and cause yellowing of the leaves. During the harvesting period of sweetcorn, the most appropriate temperatures are 10-16^{o}C. At this temperature, its grains contain most of the simple sugars and their conversion into starch is slow.

Sweetcorn is a light-loving plant and surpasses other plants in terms of light requirements. It does not tolerate shading at any stage of development, and under conditions of very good illumination, plant growth is more vigorous. For this reason, proper planting per unit area is important. Sweetcorn also has a low transpiration rate, but produces a lot of biomass and therefore its water needs are high throughout the growing season. It has a very well developed root system that can draw water from deeper layers of the soil and is less sensitive than other crops to short-term rainfall deficits. Sweetcorn has the highest water requirements during flowering and cob setting.

Among other climatic factors, strong winds have a negative impact on sweetcorn yields, as they can worsen thermal conditions and carbon dioxide concentrations by limiting the intensity of assimilation, thus negatively affecting yields. More serious yield damage can be caused by hail during flowering.

The climatic requirements for sweetcorn can be fully met in most regions of Poland and therefore its cultivation is not subject to regionalisation.

3.2. Soil

The most suitable for sweetcorn are humus soils with high water holding capacity, warm, airy soils, rich in nutrients, i.e. chernozem, black earth and loess soils. It can also be grown successfully on lighter fen soils, loamy sands and light to medium podzolic soils. The efficient water management and deep root system of maize allow it to be grown on lighter, more sandy soils that are also suitable for potatoes. The field aspect is very important. The southern aspect is the best, so the soil warms up quickly in spring. Sweetcorn has no higher requirements for soil pH. On lighter soils, however, the pH should not be lower than 5.5; and on dense soils not lower than 6.5. However, it develops and yields best on soils with a pH close to neutral.

The soils present in Poland are sufficiently beneficial for the cultivation of sweetcorn throughout the country.

3.3. Precursor crop

Sweetcorn is sown in crop succession only in the main crop. There are no special requirements for the precursor crop. On lighter soils, root crops on manure are the best precursor crop. Good precursor crops include small-seeded legumes, followed by large-seeded legumes, legume-grass mixtures, industrial crops, legume-cereal mixtures and cereals.

Sweetcorn does not react with a sharp drop in yield when grown in monoculture, but it cannot be grown successively in IP – mainly because of the potential for serious disease, pests and weeds to occur, which significantly reduce the height and quality of the harvested material. This is important because this is a typical food plant that has to meet very strict quality standards. For phytosanitary reasons, sweetcorn should not be grown more often than every 3-5 years in the same field. Sweetcorn (also known as sugar corn) is a good pre-cream for other crops, especially springs. Although sweetcorn is a vegetable, it should not be sown on a site where a year earlier was grown feed (ordinary) maize classified as agricultural crops. This measure aims to improve the phytosanitary condition of plants. It is also important, where technically possible, to isolate this vegetable crop from fodder maize crops to avoid pollination of the plants (which is undesirable in terms of yield quality) and easy movement of pests between fields.

4. SELECTION OF VARIETIES OF SWEETCORN IN INTEGRATED PRODUCTION

Sweetcorn seed is present on the domestic market, representing both domestic and foreign breeding. Individual varieties may differ in aspects such as length of vegetative period, yield potential, yield reliability, length and shape of cob, colour of grain and cob, shape of grain, number of grains per cob, height of cob position on the plant, degree of husk attachment to cob, growth habit, susceptibility to side shoot formation, number of cobs on shoots, colour and hairiness of leaves or number of internodes on the main stem. Some varieties may also vary in their susceptibility to certain pests, but it cannot be said that there are varieties resistant to pests and diseases available on the Polish market. The key differentiating factor between the different varieties is the sugar content in the kernels, which influences the classification of this vegetable into three types: sweet varieties of the su type (sugar content 4-6%), varieties with an increased content of se sugars (sugar content 6-8%) and super-sweet sh2 varieties (minimum sugar content 8-12%). The choice of variety should be related to the type of production of this vegetable. This includes the sale of fresh cobs at the milk or milk-wax stage, as well as the processing and manufacture of, for example, canned or frozen products.

Each variety must be adapted to the soil-climate conditions of the place of cultivation. Recommendations are usually given in variety catalogues published by growers or distributors. They should take into account the biological requirements of maize that affect its proper development.

The Research Centre for Cultivar Testing in Słupia Wielka, in accordance with the Seed Industry Act of 9 November 2012 and the Regulation of the Minister of Agriculture and Rural Development of 19 September 2013 (Journal of Laws of 2021, item 1300), does not carry out official studies of economic value (EV) for varieties of sweetcorn. Unfortunately, this species has not been included in the list of vegetable and fruit plants for which EV tests are carried out for the purpose of descriptive lists after their registration in the National Register. In Poland, sweetcorn varieties are registered solely on the basis of meeting the distinctness, uniformity and stability (DUS) requirement. Currently, there are several varieties of this vegetable in the National Cultivar Register. Their current list can be found at: https://coboru.gov.pl/pl/kr/kr_odm?kodgatunku=KUW

The number of sweetcorn cultivars registered in Poland is relatively small, due to the low interest of growers in registering them in our country. This species is mainly used by the processing industry and most of the varieties available on the market are listed in the Common Catalogue of Varieties of Vegetable Species (CCV).

5. PRE-SOWING TILLAGE AND SOWING

The task of tillage is to create good conditions for uniform emergence and for the growth and development of maize plants, by improving soil water-air relations, reducing the amount of weeds and self-sowing of the precursor crop plant, enabling crop residues and mineral fertilisers to be mixed into the soil without reducing the activity of beneficial soil microorganisms. Tillage should be carefully carried out to prepare the conditions for optimal plant development.

5.1 Tillage

Sweetcorn cultivation begins in the autumn, immediately after the precursor crop has been harvested. In conventional cultivation, the basic tillage operation is pre-winter ploughing, usually to a depth of 25-30 cm. Depending on the precursor crop, this is preceded by shallow tilling or loosening with a disc harrow if potatoes have been grown as a precursor crop. Spring ploughing, which dries out the soil, is not recommended. If manure is used, it is best to plough it in the autumn. Spring tillage operations include early dragging or harrowing, possibly repeated as necessary to control weed emergence and soil crusting. One to two weeks before sowing, the soil can be warmed up with a cultivating unit consisting of a rigid tine cultivator and a string roller. Its working depth should not exceed the sowing depth, i.e. 5 to 10 cm.

In our country, traditional ploughing dominates. However, this system of tillage can have negative effects such as: destruction of soil structure, risk of water and wind erosion, high labour and energy requirements. In fodder maize (an agricultural crop), non-inversion tillage and various variants of its implementation are becoming increasingly common. This includes shallow tillage, aggregation of machinery or the omission of some practices until zero tillage is fully implemented.

The argument in favour of the non-inversion system is undoubtedly the economic and organisational aspects, which include, among other things, less labour, lower fuel consumption and machine operation, and time savings. Ecological aspects are also important. Simplifying cultivation reduces soil erosion, retains water and increases organic matter, while crop residues provide food and shelter for animals. Although this method has been used in our country for several years, it is still controversial and is the subject of much criticism.

Many scientific reports and farmer testimonials indicate that the success of non-inversion farming is largely dependent on soil quality, weather conditions and farm equipment. Failure to loosen the soil, particularly on heavier soils, will reduce the development of root mass. Most of it develops in the upper layer of the soil profile, making it difficult for water and nutrients to be taken up from deeper layers. This type of farming makes it harder to warm the soil, so plants grow and develop more slowly. Remaining and unevenly distributed crop residues are unfavourable for germinating plants. Another particularly serious problem with non-inversion cultivation is weed infestation. Failure to mix the topsoil will result in weed seeds accumulating in the topsoil. Perennial weeds are particularly dangerous. A long-term study at the University of Life Sciences in Poznań of weed infestation in maize crops as a function of tillage, found that non-inversion tillage can have 30-90% more weeds than ploughing. Soil pests may also be a problem in non-inversion systems, especially with several years of development cycle such as wireworms and grubs. For some species, such as the turnip and seedcorn maggots, organic matter in the form of litter on the soil can make it easier to lay eggs. However, the intensity of soil pest outbreaks is very often localised.

Numerous scientific reports, backed up by farming practice, also show that non-inversion is not always economically superior to ploughing. Undoubtedly, it makes it possible to optimise work on large farms and reduce energy consumption. Sustained use of direct drilling also helps to restore organic matter reserves and soil structure damaged by intensive tillage. Unfortunately, the risk of lower yields after switching to direct drilling technology is one of the main deterrents for farmers. One of the main causes of lower yields is a reduction in plant density. Soil without cultivation is cooler and retains moisture longer, which is positive due to the water management of the role, but it slows down plant emergence and sweet corn responds strongly to soil temperature during emergence and early growth.

Strip tillage is another way of working the soil for maize. The formation of ruts and localised soil compaction can cause uneven emergence and weaken young plants, as the roots of the crop only develop in the loosened strip and nutrient and water uptake is hampered. There are few literature reports regarding the use of simplifications in sweetcorn cultivation under the conditions of our country. A full evaluation of their use in this plant is therefore still awaited.

5.2. Sowing

Sweetcorn seed should only be bought in the original packaging from the breeding and seed companies. In the integrated production of sweetcorn, it is mandatory to use certified seeds and to sow them within the prescribed period, with the appropriate standard and parameters of sowing, with spatial separation from other maize crops.

Sowing time

In our climatic conditions, sowing sweetcorn directly into the ground is recommended from the first half of May, when the soil has warmed up to a temperature of about 10^{o}C, as this is the temperature at which the seeds begin to germinate. If weather conditions are favourable, sowing can take place in April, especially in the south of the country. When growing sweetcorn, it is possible to see staggered sowing, which allows fresh cobs to be supplied to the market over a longer period.

For rapid and complete emergence and good growth and development, maize requires a higher temperature of 16 to 27^{o}C. Early sowing does not generally produce good results, as seeds germinate poorly in cold soil and are exposed to rot, and emerging plants die from frost during this period. As sowing too early is risky, cultivars with the shortest possible vegetation period should be used. Most extra sweet cultivars require a higher germination temperature and are therefore usually sown later.

In recent years, a number of studies have been carried out in the country on the effect of sowing conditions on sweetcorn yield and quality. At the University of Agriculture in Krakow, studies on three national cultivars of hybrid sweetcorn have shown that the harvesting period of the cobs can be extended from 1 to 2 weeks by using different sowing dates.

It is also possible to find sweetcorn being grown from seedlings in order to bring forward the harvest date and obtain a higher price for fresh cobs. The seedlings can be grown in tunnels and then planted in the ground, where they can be periodically covered with non-woven fabric, plastic sheeting, etc. to protect them from the cold. This method is usually used on smaller farms.

Plant density, row spacing, sowing depth

The weight of 1000 sweetcorn kernels varies between 110 and 270 grams, depending on the variety. The plant density per 1m^2 should be between 5 and 8 plants. Under more favourable soil and climatic conditions, it is recommended to use a higher planting density, while under less favourable conditions, the planting density should be lower. Plant population is also correlated with the vegetative period of the variety. Higher densities are used for early varieties and lower densities for later varieties.

Too many plants per 1m will result in incomplete graining of the cobs (tops). This is a negative characteristic that is important for the needs of a fresh market. Each cob (a good cob) should be completely grained. Too low a plant density per 1 m^2 often results in the formation of two cobs, which is undesirable. Two cobs usually extend the harvest date and the second cob is usually of lower quality. Placing the plants in a square will certainly give the best results, as this is where the best pollination takes place. Sweetcorn is usually sown in rows, 50 to 75 cm apart, with 17 to 40 cm between plants in the row. The spacing between rows and the distance between plants in a row depends on the vigour of the plants (varieties). Smaller plantations are sown by hand with a hoe. Larger plantations use pneumatic seed drills to ensure even seed distribution. When sowing by hand, we usually sow 3-4 seeds at a time at a depth of 5-6 cm. After the plant has emerged, the sowing should be interrupted, leaving one plant in one place. Where possible, seed should be treated with seed treatments against bird and fungal diseases before sowing.

For sowing, we use only seeds with proven vigour and germination. The amount sown depends on the value of the seed. With a possible lower seed value, we need to adjust the seed rate and put more seed per nest accordingly. Maize seed must come from specified sources, with a certificate on the packaging. It is absolutely not advisable to use so-called home-grown seed, as maize varieties are mostly hybrids and there is a strong segregation of traits in the second generation.

When growing sweetcorn, it is extremely important to maintain proper spatial isolation from grain maize or maize grown for silage or biogas. This distance should be more than 300 metres, with a minimum of 100 metres. This is very important because at shorter distances sweet corn can be pollinated by high starch fodder maize. This will cause sweetcorn to regain its ability to bind starch (lower quality). Super sweet cultivars also require a distance of 100-300 m from normal sweet cultivars, as pollination reduces their value.

6. SUSTAINABLE SWEETCORN FERTILISER SYSTEM

Fertilisation is one of the most important yield factors in sweetcorn. As the cost of mineral fertilisers continues to rise, it is important to know how to use them efficiently. Sweetcorn has a high nutrient uptake from the soil (100-120 kg N/ha, 70-90 kg P_2O_5/ha, 150-200 kg K_2O and about 30-40 kg MgO/ha) and therefore requires high fertilisation. In integrated maize production, fertilisation should be carried out at appropriate times and doses, depending on soil type and pH, after a documented nutrient balance has been established. Its nutritional needs can only be met by mineral fertilisation, although it is also grateful for organic fertilisation (mainly manure applied in the autumn). A manure application rate of 30 t/ha will provide approximately 120 kg N, 90 kg P_2O_5, 180 kg K_2O and 50 kg MgO. The first year application rate is 30% for nitrogen and phosphorus and 80% for potassium. The use of manure in lower doses and on weaker soils requires complementary mineral fertilisation. Therefore, the amount of mineral fertiliser that can be rationally and economically applied depends on the fertility of the soil, the availability of nutrients in the soil, the moisture conditions and the expected yield. However, high yields of good quality are only possible with a balanced supply of nutrients throughout the growing season.

Nitrogen

Sweetcorn is a plant with high nutritional needs. Achieving high yields and quality is only possible if plants are properly supplied with nutrients throughout the growing season. The nutritional requirements of maize increase as it grows, particularly with regard to nitrogen (N), which takes up most during generative development. Therefore, the use of nitrogen in maize cultivation should be based on the maximum efficiency of the component used, which can only be achieved under conditions of optimised fertilisation with other nutrients. Nitrogen application is not a simple issue, especially for those farmers who treat this crop as a crop capable of producing high yields in all, even the most difficult, conditions. Contrary to this view, maize, as one of the few species able to assimilate carbon via the C_4 pathway, requires not only warmth but also a good supply of nutrients and a suitable soil pH (pH 6.0-7.2). The basis for achieving high maize yields is the growth conditions at the juvenile stage (BBCH 15/16), when the primary generative yield structure is formed. The second critical phase of maize nitrogen requirements is from BBCH 16/17 to full panicle formation. It should be borne in mind that nitrogen deficiency is not always due to a physical lack of a component in the soil, but often to a lack of potassium in the diet, which causes growth to be too slow. The increase in maize yields due to the higher nitrogen efficiency of the fertiliser always leads to higher specific potassium consumption. It indicates the principle of efficient nitrogen management by corn, based primarily on optimal potassium nutrition, which leads to an increase in unit nitrogen productivity.

The most precise way to calculate the amount of nitrogen applied under maize is to make a balance sheet for this nutrient. This method takes into account the quality and type of soil, the mineralisation of organic matter from crop residues (type of precursor crop), the organic fertilisers applied and the need for liming. However, a far better method of determining soil mineral nitrogen abundance is to conduct the N_{min} test. It consists in determination of two forms of nitrogen in spring: NO_3 (nitrate form) and NH_4 (ammonium form) in a 60 cm soil profile. Knowing the amount of mineral nitrogen in the soil and the unit requirement of maize in relation to this nutrient makes it is possible to proceed to calculating the nitrogen dose. The choice of nitrogen fertiliser should primarily be based on the price of the pure ingredient and the accompanying ingredients, as maize does not require the form of this ingredient. Care should be taken not to apply too high a dose of nitrogen in the ammonium form (NH_4) just before maize sowing, as this form can easily be converted into ammonia (NH_3), especially in an alkaline environment, which leads to the loss of this component from the soil and can interfere with germination.

Due to the peculiar dynamics of nitrogen uptake by maize, the nitrogen dose should be divided and applied at two times. The first, pre-sowing part of the dose should be around 60-70% of the total maize requirement for this nutrient. If the soil is light, with a poor sorption complex, the application rate should be reduced. The rest of the nitrogen should be applied between emergence and BBCH 16/17. At this stage, the nutritional status of the plants can be assessed and, if necessary, fertilisation can be corrected. The main fertiliser for maize is a high-nitrogen fertiliser, e.g. ammonium nitrate. The total nitrogen dose can also be split and applied in other ways. The first, around 20 to 30 kg, is used at the same time as the seed is sown (line fertilisation, localised), while the rest is used mainly. However, the use of nitrogen in close proximity to the seed may cause some concern, as a local increase in fertiliser concentration may interfere with plant emergence. There are known cases of maize emergence being completely destroyed by excessive doses of fertiliser applied by this method.

A single dose of nitrogen, traditionally applied before maize, should only be used on heavy or medium soils. Pre-sowing fertilisation in the form of slower-acting nitrogen fertilisers (urea, ammonium sulphate) should be applied in one dose about 2 weeks before maize sowing. Fertilising maize with urea is highly recommended for several reasons. The first is the mutual synergy of uptake of the NH_4 form and phosphorus. A smaller amount of energy is required for the plant to convert the amide form and use it. Another reason for fertilising maize with urea is that it is easy to apply and mix with the soil. This protects against nitrogen losses in the form of ammonia and makes it independent of any surface drying of the soil. In recent years, maize producers have been using urea enriched with inhibitors of its degradation (urease inhibitors, coatings that slow the release of nitrogen). Properly applied, these fertilisers increase the dynamics of early maize growth and significantly reduce nitrogen losses.

Phosphorus

Phosphorus has important functions in plant life processes such as photosynthesis and respiration. The plant is part of organic compounds, which accumulate a lot of energy used in numerous processes taking place in the cell. Plants properly fed with phosphorus contain more vitamins and carotene and less oxalic acid, the excess of which affects the quality of the feed and food produced. With proper phosphorus nutrition, plants achieve a higher efficiency of the photosynthesis process and economical water management, resulting in an increase in grain yield and aerial dry matter yield. Proper phosphorus nutrition also stimulates the development of the root system, making plants more resistant to drought and certain diseases. A well-developed root system makes it easier for plants to absorb the water that is periodically lacking in the soil.

In maize, phosphorus is particularly important, as it has a direct effect not only on the ripening of the grain but also on its degree of development. This macronutrient is taken up by maize from the soil from the very beginning of the vegetation season, because 2 weeks after germination, the phosphorus reserves in the grain are exhausted. However, as the growing season progresses, uptake increases and continues until the grain matures. All phosphorus fertilisers available in the country can be used for maize. At the same time, it should be remembered that one way to increase the availability of phosphorus for maize is to maintain a soil pH between slightly acidic and neutral. In terms of such soil reaction, phosphorus is most readily available to the plant and then the type of phosphorus fertiliser no longer plays such an important role.

The effects of “phosphorus starvation” are more pronounced the less rich the soil is in this nutrient, the more acidic it is, and in the case of one-sided nitrogen fertilisation. The positive effect of phosphorus fertilisation is achieved on soils with low abundance and when optimal meteorological conditions prevail during the vegetation period. Although maize is a late sown crop, it is sensitive to low temperatures in the early stages of development. Limited uptake of phosphorus at low soil temperatures is caused by reduced root activity, reduced permeability of cytoplasmic membranes, increased viscosity of water. Under such conditions, the phosphorus supply of maize is limited or completely impossible. These negative phenomena can be counteracted by increasing the concentration of phosphorus in the immediate vicinity of the roots through starter (row) fertilisation. However, this method of fertiliser application requires the additional installation of a granular fertiliser applicator on the seed drill. The fertiliser is then placed 5 cm deeper and 5 cm to the side of the seed during one pass of the seed drill. However, it should be remembered that if the mineral fertiliser is placed too deep as a result of row fertilisation, the use of the mineral fertiliser component will be reduced.

Two-component fertilisers containing nitrogen and phosphorus, e.g. ammonium phosphate, should be used for starter fertilisation. The combination of these two components increases phosphorus uptake by maize in the early stages of development. However, it is important to remember that the rate of uptake of phosphorus depends on the form in which the plant takes up nitrogen. When plants are supplied with ammonium nitrogen $N\text{-}NH_4$, there is a release of H^+ from the cells into the soil solution, causing acidification, which generally increases the phosphorus concentration and the rate of uptake. When supplied with the nitrate form of nitrogen N-NO_3, HCO_3^- and OH^- ions are excreted from the cells, alkalising the soil solution and reducing phosphorus uptake. If there is a lack of phosphorus in the nutrient environment, plants take up little nitrogen, while if there is too much phosphorus, nitrogen uptake is limited. Therefore, only the right N:P ratio for a given plant will ensure its proper growth and development. The best N:P ratio is found in ammonium phosphate.

Potassium

Potassium (K) uptake by maize is highest from BBCH 15/16 until flowering, after which demand for this nutrient gradually decreases. During this period, maize is very sensitive to water shortages. The negative coupling of these two factors leads to a drastic reduction in maize yields. Sufficient potassium in the soil enables maize to use water efficiently, which affects flowering and kernel setting. Potassium deficiency weakens photosynthesis, worsens plant water management during droughts, which severely limits grain yield and green mass, and reduces maize resistance to disease and unfavourable habitat conditions. A potassium deficiency is manifested in inhibited plant growth, an unnatural dark green colouring of the leaves, formation of necrotic spots on leaf margins, poor grain filling, and an increased tendency to lodge, especially with intensive nitrogen fertilisation. The starting point for determining the potassium application rate for maize is to determine the nutrient content of the soil.

In addition to the nutrient content of the soil, the agronomic category of the soil is also very important. Knowing the soil nutrient content, the nutrient requirements and the size of the expected yield can fully balance the nutritional needs of the maize in relation to this ingredient. Among pre-sowing potassium fertilisers, potassium sulphate or high potassium salts are the best. Potassium fertilisers for sweetcorn are best applied in a single pre-sowing application during the soil preparation period before planting (autumn).

Magnesium

Maize is a plant with high nutritional requirements for this ingredient. During the year, it accumulates between 30 and 50 kg of MgO/ha. Magnesium deficiency is most common in adverse climatic conditions and poor soil structure. Symptoms of magnesium deficiency in young plants are the formation of light discolouration along the leaf nerves, and later disruption of flowering and pollination, which reduces cob setting and worsens graining. The choice of magnesium fertiliser depends on the soil reaction as well as the abundance of this nutrient in the soil. On acid soils we use lime-magnesium fertilisers, on soils with regulated pH but low Mg content we use magnesium sulphate fertilisers, and on soils with regulated pH and medium Mg content we use magnesium fertilisers with NPK + Mg base fertilisation. The magnesium requirements of maize can be met with e.g. kieserite, kainite and field liming with magnesium-containing lime fertilisers: dolomite, magnesium oxide lime, magnesium carbonate lime (soil deacidification + magnesium supplement). The optimum time to apply magnesium fertiliser is in autumn under pre-winter ploughing.

Magnesium in maize cultivation can also be applied in a foliar manner. This method of application is one of the most effective, as if the plant is deficient, symptoms of deficiency can be remedied very easily. For cereals, including maize, foliar application of magnesium is recommended at two critical growth stages, BBCH 15/18 and post-flowering. In the first period, magnesium uptake cannot keep up with the rapid elongation growth of the plant, resulting in a decrease in magnesium concentration in the plant and a deficiency. Magnesium applied directly to the leaf by spraying works almost immediately and where the nutrient is needed. This should also explain the greater efficacy of foliar magnesium application compared to soil fertilisation in the juvenile development stage of maize. In turn, during the second critical period of demand for this macronutrient, assimilates produced in the leaves are transported to the seeds in the form of sucrose. Therefore, the longer the leaves remain green, the longer the period of assimilate transport to the kernels.

Calcium

Calcium is a nutrient found in the soil in sufficient quantities for maize. Its deficiency can only occur with a high NPK mineral fertiliser, and is manifested by curling and sticking of the leaves. However, it should be remembered that field liming is a treatment that improves soil structure, increases soil microbial activity and improves nutrient availability (e.g. phosphorus availability at slightly acidic and neutral pH). Calcium fertiliser is required if the soil pH is below 5.5. The dose and form of lime for maize are determined by the need for liming and the agronomic category of the soil.

Sulphur

Sulphur is an important nutrient, essential for proper plant growth and development. The decline in sulphur dioxide emissions in recent years, high crop yields and the use of fertilisers that have long been free of this ingredient in most parts of the country have worsened the supply of sulphur to crops. In addition, a reduction of organic fertiliser by almost 50%, including manure, where we added about 8 kg of elemental sulphur at a dose of 10 t/ha, resulted in soil depletion of this macronutrient. With sulphur deficiency, the protein content of the plant decreases, a clear symptom of which is inhibited growth. Moreover, sulphur deficiency leads to a reduction in the efficiency and use of nitrogen from nitrogen fertilisers. Each missing kilogram of sulphur per hectare results in an average of about 15 kg of nitrogen not being used by plants. Maize is a crop with a relatively low sulphur requirement, but is a high yielding crop with large amounts of nutrients, including sulphur (35-50 kg S/ha).

When determining the amount of sulphur, account should be taken of the abundance of soil and the needs for this component. However, it is important to remember that too much sulphur in the fertiliser will lead to lower yields and loss of components. The right dose of sulphur is particularly important when high doses of nitrogen are used, as sulphur not only affects yield but also nitrogen use. Sulphur deficiency in the soil can be remedied by applying fertilisers containing sulphur as a by-product, e.g. ammonium sulphate, potassium sulphate, simple superphosphate.

In the Integrated Plant Production system, the use of sewage sludge, digested sludge and other sludge of unknown composition for fertilisation purposes is prohibited due to the risk of introducing unmonitored hazardous substances into the secondary cycle, which can accumulate during the production process.

7. INTEGRATED PROTECTION AGAINST AGROPHAGES

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

Plant protection products to be used in accordance with the current maize protection programme for integrated production (IP) / and in accordance with the recommendations on the label and in a way that avoids risks to human, animal or environmental health.

The list of plant protection products authorised in Poland is published in the relevant register. Information on the scope of application of pesticides in individual crops is included on the labels. The pesticide search engine is a tool to assist in the selection of pesticides. Current information on the use of plant protection products may be found on the website of the Ministry of Agriculture and Rural Development at https://www.gov.pl/web/rolnictwo/ochrona-roslin

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

For protection against agrophages (weeds, diseases, pests), only products registered and authorised for marketing and use in Poland may be used which are clearly indicated on the labels attached to the packaging as recommended for use in maize cultivation. **It should be borne in mind that sweetcorn is a vegetable, so the same products cannot be applied by analogy to the production of fodder maize in its sowing, unless the label of the preparation is registered for that crop.**

It should be borne in mind that the products included in the protection programme do not present a risk when properly applied in accordance with the approved labelling of the plant protection product. Compliance with the instructions for use, such as, among others, the appropriate choice of the product, the dose, the date of application, the appropriate stages of development of the crop and pests, the appropriate temperature-humidity conditions and the technical conditions for the performance of the treatment, have a decisive influence on the safety of treatments with plant protection products.

In integrated sweetcorn production, the rotational use of plant protection products from different chemical groups is very important to prevent the phenomenon of resistance in pests (weeds, pests and pathogens), taking into account the level of protection in previous seasons.

7.1. Weed infestation control

Skilled management of weed infestations is critical to maintaining production profitability. The losses caused by weed infestation in sweetcorn are greater than those caused by other pest groups. Weeds are an integral part of cultivated fields and their diaspores in the soil (seeds, rhizomes, runners, bulbs) are the main cause of weed infestation. Weed infestations occur when unwanted vegetation is present in quantities or biomass that cause direct or indirect economic loss. Economic losses as a result of a weed infestation may result from a decrease in the quality or quantity of yield, a depletion of value or an increase in labour intensity and energy intensity of production.

The amount of crop losses as a result of weed infestation depends on the botanical composition of weeds and the period during which infestation occurs. The types and abundance of weeds that will occur in the field are determined by factors such as the weed diaspore-reserve in the soil, soil and climatic conditions, and agricultural practices, particularly the crop treatments used. Hence, the botanical composition of weed infestation in different regions of the country and even within adjacent fields can vary significantly.

Weeds and the associated risk of weed infestation depend on habitat conditions and the rhythm of crop development. As a permanent feature of arable fields, weeds have a natural ability to exploit habitat conditions, giving them an advantage over crops. This is due to their survival, physiology and life cycle strategies and their adaptive ability to compete for access to water, nutrients and solar radiation.

7.1.1. The most important weed species

In maize sowings, annual species are most common. The most common monocotyledonous weeds are the pigweeds (barnyard grass, crabgrass, foxtail) and the dicotyledonous weeds are goosefoot, amaranth, the chamomile weeds (mayweed, field camomile, chamomile) and knotweeds (pale persicaria, lady's thumb, common knotgrass, back-bindweed). In addition, other annual dicotyledonous species are common, including cranesbill, common mugwort, cornflower, fumewort, field dye, violet, field mustard, common chickweed, common stork's-bill, dead-nettles, poppy, common sowthistle, common purslane, hemp-nettle, veronica, catchweed, black nightshade, wild radish, flixweed, shepherd's purse, field pennycress, velvetleaf, and potato weed. Of the perennial weeds, field milk thistle, creeping thistle, couch grass and field bindweed are locally present. More and more often, especially with simplified cultivation methods, weeding of self-sowing crops, mainly rape and cereals, and in recent years also sunflowers. Each time, it is necessary to check which undesirable species of vegetation are present in the area where the maize is to be grown, especially if the fields are new and the phytosanitary situation is not yet known to the farmer.

7.1.2. Agrotechnological methods of weed management

Integrated weed management should be based on preventive treatments and direct methods to reduce weeds. The basis of non-chemical weed control is crop succession. The main source of weed infestation is the resources of viable weed diasporas accumulated in the soil. They create the so-called 'potential weed infestation' (soil) – or the sum of weed diaspora accumulated in the cultivated layer of the soil, capable of germination. The species composition and quantity of viable weed diaspores, the so-called "soil seed bank", depends on, among other things, agro-technical measures, especially crop succession, cultivation and weed control. On the other hand, "current weed infestation" refers to weeds occurring within the crop stand.

Weed control measures should aim to reduce the soil bank of viable weed diaspores through various types of intervention, with the end result being a systematic reduction in the number of active weed diaspores.

Weed control in sweetcorn should be adapted to the cultivation method, depending on whether it is a traditional ploughed crop or a crop based on simplification to reconcile the needs of the crop with the requirements of soil, water and air conservation, such as no-tillage, direct drilling or strip-tillage. A significant reduction in the number of active weed diasporas, including self-seeding of arable crops, occurs in a group of crops after harvest of the pre-harvest crop or in cultivation practices before sowing.

The greatest losses are caused by weeds, which appear in the early stages of maize development. As a result of the low planting density, wide row spacing and slow initial growth, maize is slow to cover the inter-rows. It needs intensive care during this time. This is known as the "critical period of weed competition" – the period during which weed emergence and development should be limited as much as possible to avoid crop losses. Reducing the negative impact of weeds on maize plants during this period is critical to achieving optimum yields. Weed control can be carried out mechanically or chemically using herbicides.

Sweetcorn plantations – where possible, mechanical weeding should be the first step. Hoes or weeders of various types with passive or active working elements are most commonly used to destroy weeds in the inter-row until they are covered by the crop. This method may not be fully effective in controlling all weeds, particularly those growing in and around the rows or those that emerge between rows after mechanical weeding.

In integrated production, treatments should be used to reduce potential and current weed infestation. Among the most important, the following should be recommended.

- Proper site selection for buckwheat cultivation, taking into account the correct crop rotation.
- Weed control in a post-harvest tillage unit and of a precursor crop plant.
- weed control should be carried out by mechanical or chemical means using one of the recommended plant protection products as recommended on the product label,
- Cultivation operations should carried out as needed and in a way that does not lead to soil pulverising and drying out;
    - the use of hygiene measures to clean machinery and equipment of weed diasporas (e.g. couch grass rhizomes or plume thistle stolons) to prevent the spread (dispersal) of weeds,
    - use of certified seeds. Adequate quality seed ensures a fast, even emergence and planned plant density, provided that sowing is carried out under optimal conditions (sowing date, sowing depth, soil temperature and moisture, etc.);
    - the use of balanced fertilisation enables harmonious development of the crop.

7.1.3. Chemical weed control methods

In the chemical method, great emphasis is placed on the correct application of sprays by an authorised professional user using certified sprayers that are properly calibrated and fully technically efficient with up-to-date technical testing.

It is also very important to respect the principles of appropriate herbicide selection, in particular the recommended doses and dates of application, while trying to limit the number of treatments and the amount of plant protection products used to the minimum necessary. The selection of plant protection products and the way in which treatments are carried out should be such as to minimise the negative impact of plant protection treatments on non-target organisms.

When selecting chemical herbicides, consideration should be given to countering the development of weed resistance to herbicides by rotating herbicides with different mechanisms of action according to the HRAC (Herbicide Resistance Action Committee) classification or those belonging to different chemical groups.

It should be borne in mind that in integrated production (IP) of sweetcorn, only herbicides recommended for IP vegetable crops that include this maize subspecies can be used.

The use of plant protection products must be in accordance with the information on the label. A tool to assist in the selection of an active ingredient can be the plant protection product search engine and up-to-date information on the use of plant protection products, which can be found on the website of the Ministry of Agriculture and Rural Development at the following address https://www.gov.pl/web/rolnictwo/ochrona-roslin. Detailed information on registered herbicides for the protection of sweetcorn can be found at the link https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie. The list of measures approved for integrated production is available at https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji

7.2. Reduction of disease perpetrators

In Poland, sweetcorn sowings are affected by the same diseases as the so-called fodder maize (regular maize) crops. The level of severity of pathogens can vary between regions of the country as well as between different fields. Pathogens affecting sweetcorn can be transferred from fields sown with other types of maize.

7.2.1. Most important diseases in maize cultivation

Maize plants in Poland are threatened by several hundred pathogens, which are responsible for the development of many diseases. Currently, pathogenic fungi are the most numerous, and also the most dangerous group. In recent years, increasing attention has also been paid to viruses and pathogenic bacteria that can infect maize plants, some of which can be actively transmitted by insect vectors. At this point, only certain fungal diseases are causing crop losses. These diseases include:

Seedling blight – is caused by fungi of the *Fusarium* genus that can produce mycotoxins and fungi of the *Pythium* genus. The primary source of maize infestation is infected soil, crop residues, or seed. The development of the disease is favoured by sowing too deep or too early (especially untreated) in poorly heated soils, and by cold and wet weather during germination and emergence. The pathogen mycelium develops on the outside and inside of infected tissues leading to their death. Disease symptoms first appear on the caryopses in the form of dying sprouts and formation of brown spots which are often followed by grain cracking and secondary infections by various pathogens. No emergence is then observed on the field surface. On the roots of seedlings and young plants and at the base of the stem, yellowish, later brownish spots appear in turn, gradually turning into blackened streaks. Severe damage to the roots, especially the root collar, leads to wilting, yellowing, and plant loss. Occasionally, poorly infested plants do not die but continue to grow, becoming more susceptible to infection by other pathogens, especially those causing root rot and basal stem rot.

Corn smut (commonly known as galls) develops in the aftermath of fungus infestation of plants *Ustilago maydis*. Soil, maize residues, or infected seed are the primary source of infection. Up to three generations of this disease can develop during the vegetation season. The first occurs when the plants develop their fourth to seventh leaves, the second during flowering and the third when the kernels are filled and ready for milking. The development and spread of the disease in the canopy are favoured by damage, particularly by frit fly, aphids and thrips, and later by European corn borer and other cob pests. Disease symptoms take the form of outgrowths (nodules) located on leaf blades, stems, tassels and cobs inside which a cluster of clumped, grey-black spores can be found. Initially, the outgrowths are bright in colour; over time they turn brown, wrinkle, and crack. Each outgrowth is the result of a separate infection of the fungus because corn smut, as opposed to the head smut of maize, does not develop systemically. From an economic point of view, the most dangerous are the first and second generations of the disease which can sometimes seriously deform or even destroy plants. Plants infested during the development of the fourth to seventh leaves and during tassel emergence and pollination may not produce cobs at all. Late infections mainly result in yield quality decline, however, the perpetrator of corn smut has not been shown to produce mycotoxins. The detrimental effect of corn smut is a reduction in grain yield and a deterioration in grain quality. The disease also reduces the commercial value of cobs for direct sale. Endospores of the smut remain capable of infecting for 3 years.

Head smut of maize it is caused by a fungus. *Sphacelotheca reiliana*. The primary sources of infection are soil, crop residues and infected seed. Although the pathogen infects maize directly at the beginning of vegetation, i.e. during germination and emergence, it develops in the tissues for several weeks (systemic infection) and the first symptoms of disease are not seen until July. Infected plants are usually lower than healthy ones and pale green. Lesions are visible on the cobs and, to a lesser extent, on the tassels. These organs completely or partially transform into a dark brown or black mass of mycelium and spores. Initially, the sporangia are surrounded by a light grey delicate membrane which then bursts, releasing the spores. Tassels with disease symptoms look as if they have been burnt. Severely infested plants do not produce cobs which can lead to a complete loss of yield. It is estimated that the percentage of plants affected by head smut in a plantation corresponds to the same loss in cob yield. Harmfulness of this disease is also enhanced by the very long survival period of the spores in the soil, which is up to 10 years.

Root rot and stem base rot (Fusarium stem rot) develop as a result of infection by fungi of the genus *Fusarium*. The primary sources of infestation are spores in the soil, on crop residues, and also those carried by wind or water. Fusarium fungi may also be present at the site after the harvest of precursor crops if they were infected, as they are usually polyphagous organisms. The disease can also develop following previous infection of plants by seedling blight. The first symptoms of the disease are visible in July in the form of wilting and drying of the leaf blades from the bottom upwards. Over time, whole plants become chlorotic and weakened in growth. Blocked vascular bundles in the stems limit the nutrition of the cobs, which are a commercial crop. In warm and humid weather, rotting of the tissues inside the stem quickly occurs, rendering the plants incapable of staying upright and causing them to break in areas of severe infestation Infected tissues inside the stems usually turn reddish or salmon-coloured. The development of the disease is facilitated by the damage caused by the European corn borer. The perpetrators of root rot and basal stem rot, in addition to their direct impact on grain yield, have the ability to produce mycotoxins.

Fusarium cob rot – develops when plants are attacked by fungi of the genus *Fusarium*. The primary source of infection includes fungal spores in the soil and on maize residues. The disease may also occur as a result of earlier taking over of plants by the root rot and basal stem rot when the mycelium overgrows into the cobs. It has also been shown that the European corn borer can be a vector for fusarium fungi. The development of Fusarium cob rot is favoured by warm, wet summers and damage from pests, particularly European corn borer, corn rootworm, cutworm, owlet moth and four-spotted sap beetle. The first disease symptoms are visible at milky and dough grain maturity on cob cover leaves and kernels in the form of white, pink, or red mycelium. Early cob infestation usually results in greying, browning and kernel death. Later infections, however, lead to poorer grain filling, dulling and cracking as well as infestation by other pathogens, including *Trichoderma, Penicillium and Trichothecium* fungi. The perpetrators of corn cob fusariosis have the ability to produce mycotoxins.

Eyespot is caused by the fungus *Aureobasidium zeae*, which hibernates in the soil and on maize crop residues. The disease appears more intensely in cool and wet summers. Under high humidity conditions, fungal spores are transferred to plants by wind or raindrops splashing on the soil surface, and infection is facilitated by tissue damage caused by pests with penetrating sucking mouthparts (aphids, thrips, leafhoppers, spider mites, lygus bugs and others). For infection to occur, the leaves must be moist, so heavy infestations usually occur during rainy weather or prolonged periods of dew and fog. The first symptoms of plant infestation can be observed in June or July. Initially, these are small, chlorotic spots on leaves, leaf sheaths and cob cover leaves that are clearly visible under light. Later, the centre of the spots becomes necrotic, surrounded by a reddish-brown ring and a translucent light-coloured border. The spots gradually enlarge and merge together, covering a large part of the infected organs. It is possible for the pathogen to occupy more than half the surface area of the largest leaf plaques, causing them to become severely dysfunctional. Disease symptoms initially appear on the lowest leaves, gradually moving to higher parts of the plant. The disease mainly contributes to a reduction in the assimilative area of the plant, a deterioration in kernel nutrition and thus a reduction in the size and quality of the marketable yield.

Northern corn leaf blight (commonly known as Helminthosporium leaf blight) — develops in the aftermath of infestation of plants by fungi of the genus *Helminthosporium*, including *H. turcicum*. The primary source of infestation is soil and maize residues. The best conditions for the disease to develop are in warm and moderately rainy summers. The spread of fungal spores in the field is favoured by wind as well as tissue damage caused by pests with piercing-siphoning mouthparts. The first symptoms usually appear on the lower leaves in

July. Later, they gradually move higher and higher up to the cover leaves of the cobs. They take the form of greyish-brown spots surrounded by a reddish-brown margin. The discolourations are oval, elongated, irregularly shaped, usually arranged along the veins. As the infection progresses, the spots merge to cover much of the aboveground plant organs. Severely affected leaves dry up and whole plants are weakened by a decrease in assimilative surface area. Severe infestation results in premature maturity and poor grain filling, leading to a reduction in yield and quality.

Common rust of maize – its perpetrator is the *Puccinia sorghi* fungus which overwinters on maize residues or its spores are transferred to maize from a spring host which is a common weed called oxalis (wood sorrel). Common rust of maize finds the best conditions for development in warm and humid summers, and the spread of the pathogen in the plantation is favoured by wind and damage caused by pests with a piercing-siphoning mouthpart. The first disease symptoms appear from June onwards. Rust-coloured, elongated, pillow-shaped sporangia form on the leaves. They are scattered over the entire surface of the leaf blades on both sides. With heavy infection, disease symptoms are also visible on the stems and cover leaves of the cobs. Towards the end of the vegetation season, brownish-black pads with endospores appear on the leaves. Small infestations on individual leaves do not affect yield, whereas heavy infestations lead to a significant reduction in the assimilation area, resulting in premature ripening and dieback of the maize and incomplete graining of the cobs. The height and quality of the cob crop may be reduced.

In addition to diseases caused by pathogenic fungi, sweetcorn crops can be affected by the oomycete *Sclerophthora macrospora*, which is responsible for the outbreak of crazy top disease. This disease can occur locally in the summer during heavy rainfall after maize emergence, when water stagnates in the fields. Maize is also infected by viruses and pathogenic bacteria, but their economic importance is still limited. Plant viruses can cause diseases such as maize dwarf mosaic virus (MDMV, SCMV), brome mosaic virus (BMV), wheat streak mosaic virus on maize (WSMV) and barley yellow dwarf virus on maize (BYDV-MAV, BYDV-PAV, CYDV-RPV). Pathogenic bacteria in maize crops can cause diseases such as bacterial leaf spot of maize (*Pantoea ananatis*), bacterial stem rot (*Enterobacter cloaceae* subsp. *dissolvens*) and leaf blight and vascular wilt of maize and sorghum (*Pantoea agglomerans*). It should be remembered that the spread of viruses and disease-causing bacteria encourages the presence of pests, some of which may be vectors.

The current significance of sweetcorn diseases is shown in Table 1.

Table 1. Economic importance of selected perpetrators of sweetcorn diseases in Poland

Disease	Current economic importance
Eyespot (*Kabatiela zeae*)	++
Maize cob fusariosis (*Fusarium* spp.)	++ (+)
Corn smut (*Ustilago maydis*)	++ (+)
Head smut of maize (*Sphacelotheca reiliana*)	+
Common rust of maize (*Puccinia sorghi*)	++
Root rot and basal stem rot (*Fusarium* spp.)	++ (+)

Seedling blight (*Fusarium* spp, *Pythium* spp.)	+ (+)
Yellow spot of corn leaves (Helminthosporium spp.)	+

+ small; ++ medium, +++ large

7.2.2. Methods for monitoring disease perpetrators in maize cultivation

In the integrated method of protection, it is important to know both the primary sources of infection, i.e. the places where the pathogen exists as well as the detailed weather conditions that promote the development of disease perpetrators. The more favourable the conditions for the development and spread of the pathogen, the greater the intensity of disease outbreaks and the associated yield losses they cause.

Currently, there is no system in place to support decisions on disease protection for sweetcorn in the country's territory, so decisions on the need to carry out the procedure should be based on our own observations and experience. The severity of the diseases should be recorded annually, so that the risk of their occurrence in the next growing season can be predicted.

Accurate and frequent observation of the plantation provides much of the essential information needed to manage the crop. This indicates the presence and severity of various pests, including pathogens. In this respect, it is important to know the history of the field, i.e. whether and what diseases and in what severity were previously observed in this area. It is important whether these were pathogens that could survive in the soil for many years.

The decision to use emergency protection against diseases should be based on one's own monitoring of the phytosanitary condition of the plantation and experience, as economic thresholds for the harmfulness of diseases of this plant have not yet been developed.

To determine the timing, intensity and severity of maize fungal diseases, it is essential to carry out systematic crop observations from the time the kernels are sown until the cobs are harvested. In the event of early spring diseases affecting germination and emergence, it may be necessary to excavate kernels in areas where emergence has not occurred, or to assess the root system of dying seedlings to determine the cause of maize dieback.

In the case of diseases caused by the development of the first leaves of the plants, it is recommended that the development of the pathogens should be observed at least once a week throughout the growing period of maize by carefully observing at least 100 randomly selected plants at four sowing locations up to 10 hectares. In plantations of 10-50 ha, the number of observation points should be increased to at least 8-10, and in very large fields (over 100 ha) there should be at least 15-20 points. It is advisable to avoid observing plants in the edge strip, where their intensity is usually higher than deeper in the field.

To determine the severity of most maize diseases, the degree of infestation of individual organs is often calculated in addition to calculating the percentage of plants controlled. For the eyespot, northern corn leaf blight, and common rust of maize, a five-stage infestation scale is usually used where the first stage means an infestation of 0.1-5.0% of the leaf blade area while the fifth stage means an infestation of more than 50% of the leaf area. A five-stage scale is usually used for corn cob fusariosis where the first stage indicates a very small infestation (up to 2% of kernels) and the fifth stage a very large infestation (51-100% of caryopses infested). A 9-stage scale is usually used to assess the severity of root rot and basal stem rot with the first stage indicating no symptoms, the third stage indicating lesions on the first or second node, and the ninth stage indicating complete tissue decay.

7.2.3. Non-chemical methods of controlling disease pathogens

In integrated plant protection, several methods are available to limit the occurrence and spread of disease perpetrators and depend on the grower and the specificities of the cultivated species. In the case of maize cultivation, the primary method of reducing the presence of pathogenic organisms is correct agrotechnology, but attention should also be paid to other non-chemical methods that reduce the risk of disease perpetrators on the site.

Breeding method

In non-chemical methods of reducing disease perpetrators, the purchase of ‘certified’ maize seed from a known source is particularly important. To reduce the incidence of diseases such as corn smut, Fusarium cob rot, root rot and stem base rot, it is advisable to select varieties that are less susceptible to infection where these are available on the market.

Agrotechnical method

In non-chemical methods of reducing the abundance and harmfulness of disease perpetrators, an important emphasis is put on selection of the optimum growing site to ensure that the plants develop properly. Maize should not be sown on poor soils, in shady areas, in areas that are waterlogged, regularly flooded by rainwater or on hillsides that are too high (risk of soil erosion).

Many disease perpetrators overwinter in the soil and in maize crop residues, and in the case of some pathogens, their endospore stages remain viable for up to several years so using crop rotation is very important. It is recommended that maize is not grown on the same site for at least 3-5 years, depending on the local phytosanitary situation. Recommended precursor crops for sweetcorn are given in the chapter on basic crop recommendations (Chapter 3).

Spatial isolation is recommended to limit the migration of some pathogens from the previous year’s field or from other hosts. The greater the distance between the newly established maize crop and the stubble, the lower the risk of heavy infestation by these species, whose spores are also carried by the wind.

The degree of threat from many disease perpetrators can be influenced by some agrotechnical treatments. Optimal fertilisation, particularly with nitrogen, is one of them. The use of nitrogen in excessively high doses contributes to an increase in the infestation of plants by corn smut and diseases caused by *Fusarium* fungi genus. In the case of some diseases, early sowing is advisable, but in soil that is sufficiently warmed up so that the plants are more advanced in their development at the time of infection.

Weed control is also important as some weed species can be overwintering or pre-development sites for certain pathogens, an example being common yellow woodsorrel (*Oxalis stricta*), an intermediate host for common rust of maize.

In small maize plantations, direct control of some diseases can be achieved by cutting and destroying infested plants away from the plantation. This must be done for crazy top disease, corn smut and head smut, but it must be done before the clusters burst, releasing thousands of spores.

The crop should be harvested at the right time to limit cob losses in terms of quantity and quality. Immediately after harvesting the cobs, when the sweetcorn crop has finished production, it is recommended that as soon as possible a shredder be used on the stubble, which will mechanically destroy some of the pathogen spores (and some pests) and also accelerate the decomposition of organic matter by chopping the straw into chaff. This can be a mulcher, knife roller, disc harrow or any device capable of cutting or severely crushing plant tissues.

In ploughed systems, ploughing is usually done before winter to cover the overwintering stages of the pathogens with a layer of soil, making it more difficult for them to infect new maize plants in the spring. In simplified systems where only surface crops are grown, crop residues should be mixed with the top layer of soil.

A list of the most important non-chemical methods for reducing the abundance and pests of sweetcorn diseases is given in Table 2.

Table 2. Non-chemical control of maize disease perpetrators in Poland

Disease	Non-chemical methods
Bacterial diseases	
Bacterial leaf spot of maize	crop rotation, spatial isolation (e.g. from last year's maize fields, wetlands), purchase of certified seeds, early sowing, balanced fertilisation, weed and pest control, thorough crop residue shredding, winter ploughing (traditional systems).
Bacterial stalk rot of maize	
Leaf blight and vascular wilt of maize and sorghum	
Fungal diseases	
Crazy top of corn	crop rotation, spatial isolation (e.g. from last year's maize fields, perennial grasses, wetlands and periodically flooded areas), purchase of certified seeds, early sowing, balanced fertilisation, control of monocotyledonous weeds, cutting and removal of infested plants, crop residue shredding, winter ploughing (traditional systems).
Eyespot	crop rotation, purchase of certified seed, early sowing, balanced fertilisation, weed and foliar pest control, crop residue shredding, winter ploughing (traditional systems).
Maize cob fusariosis	crop rotation, spatial isolation (e.g. from last year's maize fields), purchase of certified seed, selection of (Fusarium cob rot and Fusarium stem rot) tolerant varieties, early sowing, balanced fertilisation (especially with nitrogen), weed and pest control, timely harvesting, crop residue shredding, winter ploughing (traditional systems).
Root rot and basal stem rot	
Seedling blight	
Corn smut	crop rotation, spatial isolation (e.g. from last year's maize fields), purchase of certified seed, selection of (corn smut) tolerant varieties, early sowing, balanced fertilisation (especially with nitrogen), weed and pest control, removal of infested plants, crop residue shredding, winter ploughing (traditional systems).
Head smut of maize	
Common rust of maize	crop rotation, spatial isolation (e.g. from last year's maize fields, yellow woodsorrel), purchase of certified seed, early sowing, balanced fertilisation, weed and foliar pest control, crop residue shredding, winter ploughing (traditional systems).

Northern corn leaf blight	crop rotation, spatial isolation (e.g. from last year's maize fields), purchase of certified seed, early sowing, balanced fertilisation, weed and foliar pest control, crop residue shredding, winter ploughing (traditional systems).
Viral diseases	
Maize mosaic	avoidance of waterlogged and periodically flooded sites, crop rotation, spatial isolation from last year's maize fields, sowing certified seeds, early sowing, balanced fertilisation, weed and pest control, no use of stagnant water for maize irrigation, thorough residue shredding, winter ploughing (traditional systems).
Wheat streak mosaic virus on maize	
Barley yellow dwarf virus on maize	

7.2.4. Chemical methods to reduce the perpetrators of diseases

It should be noted that in integrated production (IP) of sweetcorn, only fungicides recommended for (IP) vegetable crops may be used to include this maize subspecies.

The use of plant protection products must be in accordance with the information on the label. A tool to assist in the selection of an active ingredient can be the plant protection product search engine and up-to-date information on the use of plant protection products, which can be found on the website of the Ministry of Agriculture and Rural Development at the following address https://www.gov.pl/web/rolnictwo/ochrona-roslin. Detailed information on registered plant protection products for the protection of sweetcorn can be found at the link https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie.
The list of measures approved for integrated production is available at https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji

Based on the selection of chemical pathogens, the prevention of resistance to fungicides should be considered, taking into account their rotation with different mechanisms of action according to the FRAC classification or belonging to different chemical groups.

7.3. Reduction of losses caused by pests

In Poland, sweetcorn sowings are affected by the same pests as the so-called fodder maize (regular maize) crops. The intensity of individual herbivores can vary between regions of the country and between fields. In some cases, sweetcorn crops are more attractive to some pests (due to their higher sugar content) than fodder maize.

7.3.1. Main pests in maize cultivation

Maize plants in Poland are threatened by about 100 species of herbivores, some of which are typical pests, dominated by members of the order Insecta. Pests are often found locally and cause high levels of damage, but some species are widespread. Some species live in the soil, while others feed on the above-ground maize organs. There are also organisms whose harmful stages feed both in the soil and on the above-ground vegetative and generative parts.

Some phytophages occur only periodically, while others are present for most of the growing season. The most important pests of sweetcorn in recent years include:

Wireworms – are the larvae of beetles in the click beetle family (Elateridae). They are a typical soil pest found throughout the country, but are most abundant in maize plantations established on ploughed meadows, pastures, fallow land as well as in fields immediately adjacent to such land. The overwintering stages are beetles and larvae in various stages. Depending on the species, they take 3-5 years to develop in the soil, hence they accompany maize from sowing of the grain to crop harvesting. Despite their year-round presence in the soil, click beetle larvae are most threatening to maize at the beginning of the vegetation season. By eating the seeds in the imbibition stage and biting the roots of seedlings, they can lead to the formation of hollow spots (known as bald spots) in sown areas. At a later stage, they can bite into the base of the stems of young plants, making in them break and fall over onto the soil.

Frit fly – this is a fly in the Chloropidae family. Its legless larvae, up to 4 mm long, are harmful. This pest attacks maize throughout the country and is favoured by summers with cold springs and the presence of wild grasses and winter cereals. The species develops three generations per year, but maize plantations are threatened by first-generation larvae. The overwintering stage is the larvae found in the tissues of winter cereals (especially winter barley and winter wheat) and in cultivated and wild grasses. Adults, from the second half of April and into May, raid maize plantations when the plants are unfolding 1-3 leaves. Once the flies have laid eggs, larvae hatch after a few days and bite into the interior of young plants. Weaker signs of their feeding include bright spots along the veins of leaves, sometimes with small holes. Severe damage to the leaf blades results in leaves that are clumped, difficult to open and often ragged. When the larva reaches and damages the growth cone, the plant becomes dwarfed and produces side shoots, which usually do not form cobs. Complete destruction of the apical meristem leads to plant dieback. The frit fly is a major contributor to the increased susceptibility of damaged plants to disease, particularly corn smut.

Western corn rootworm is a beetle of the leaf beetle family. The eggs overwinter in the soil at a depth of up to 15-30 cm. The condition for the larvae to hatch is the cultivation of maize in monoculture. After sowing maize, larvae begin to hatch from April or May. Their mass appearance is usually in June, while the last few larvae can be seen until the end of August. The first beetles appear from the first decade of July, less frequently from the third decade of June. The period of their abundance is usually from the end of July to the second half of August, with a peak in numbers usually occurring in mid-August. The last individuals can be observed in late October or November. The larvae found in plantations grown in monoculture is the most dangerous developmental stage of this species. In the soil, they damage the root system of plants. Severe root damage leads to the plants lodging and arch-bending towards the sun. The beetles pose a threat only when they feed en masse on the cobs. By biting through the corn silk, they cause weaker graining of cobs and their deformation. They may promote the development of fusarium cob rot. By damaging the leaf blades, they reduce the plant’s assimilative surface area and promote the development of leaf diseases.

Aphids – are true bugs of the aphididae family. Several species are found on the aboveground parts of maize, including the bird cherry-oat aphid (*Rhopalosiphum padi*), rose-grain aphid (*Metopolophium dirhodum*), English grain aphid (*Sitobion avenae*), corn leaf aphid (*Rhopalosiphum maidis*), black bean aphid (*Aphis fabae*) and green peach aphid (*Myzus persicae*). In turn, the elm leaf aphid (*Tetraunera ulmi*) feeds on the roots of plants. Among the listed species, two are most abundant: the cherry-oat aphid and rose-grain aphid. Aphids are found throughout the country. In maize plantations, they are encountered from April or May until mid-October. Two, and usually three, peaks of abundance are observed in their development. Aphids are found on almost all above-ground parts of maize. Both larvae and adults puncture tissue and suck sap. Numerous feeding of true bugs leads to discolouration of the leaf blades and disturbance of the plants' water balance. Aphids mainly contribute to quality losses as they increase the susceptibility of plants to disease infestation. Some species are known as viral disease vectors. In addition, the honeydew produced by aphids promotes development of sooty fungi which reduce the assimilative surface area of the plants.

Thrips – are insects of two families: Thripidae and Phlaeothripidae. There are 21 species feeding on maize, with two species dominating: *Frankliniella tenuicornis* and *Haplothrips aculeatus*. Thrips are found throughout the country. They are recorded on maize from April/May to mid-October. During the growing season, there is usually one peak in their numbers, usually occurring in mid to late July. Like aphids, thrips suck the sap from the aboveground parts of plants. In the case of mass feeding, discolouration of the tissues with black dots can be seen on leaf blades which is referred to as thrips leaf spot. Direct harmfulness of thrips on maize crop yield is low. However, the indirect harm of increasing the susceptibility of infested plants to pathogen infestation is much higher.

Cutworms – these are caterpillars of moths in the Noctuinae subfamily. The turnip moth (*Agrotis segetum*), heart and dart (*Agrotis exclamationis*), setaceous Hebrew character (*Xestia c-nigrum*), and floodplain cutworm (*Agrotis ipsilon*) are usually found on maize. For maize, species that produce one or two generations per year are listed. Cutworms are found throughout the country. On maize, they are encountered from sowing until harvest. The greatest threat to the plants is in years of mass emergence which occur every few years or so. Immediately at the start of maize vegetation, plants may be damaged by overwintering caterpillars as part of supplementary feeding. After pupation, at the time maize unfolds its first leaves or first internodes, the first generation of cutworms appears. During this time, caterpillars can feed in the curled leaf blades and on roots. They eat out irregular holes in leaves, additionally contaminating them heavily with faeces. When they feed in the soil, they bite roots which makes the plants wilt, turn yellow, and dry out. In addition, they can bite into the base of the stem which leads the whole plant to be cut down. One cutworm can bite up to a dozen plants in a row in this way. The second generation of cutworms appears at the time of milk and dough of kernels. Caterpillars of this generation can feed on the roots of the plants, but also on the cobs, where they completely eat the soft kernels without disturbing the rachis. As a result of their feeding, the grain yield is reduced and, in addition, the crop is of lower quality due to the development of fungal diseases. Cutworm feeding on cobs contributes to an increase in their infestation by cob fusariosis.

European corn borer – is a moth of the Ripiphoridae family. Under Polish conditions, the species develops one generation per year, but in some years, from September onwards, a few butterflies of the second generation are possible. The overwintering stage of the European corn borer are caterpillars found in maize residues, coarse weeds, or in shoots of other host plants such as millet and hops. They spin cocoons and pupate from the end of April. The butterfly flight starts from June onwards. The peak flight of butterflies occurs in the first or second decade of July and ends in August. The egg-laying period is between 4.5 and 8 weeks. The first European corn borer egg deposits on plants are usually recorded from the second half of June. The period of their high abundance is from the end of the first to the end of the second decade of July, with a peak in abundance at the beginning of the second decade of July. The last egg deposits are encountered by the second half of August. Caterpillars start hatching from the second decade of June, while their period of abundant emergence is usually in the second or early third decade of July. The last hatching can be observed at the end of August. The European corn borer currently occurs throughout the country and is considered the most dangerous pest of maize. Its caterpillars damage almost all above-ground parts of maize plants. Economically important damage includes direct eating of the kernels out of the cobs, biting of the cobs at the base, resulting in their stripping, as well as stem breaking below the cob, especially when the whole plant falls over onto the soil. An additional harm caused by this species is the increased susceptibility of damaged plants to disease infestation, especially the fungi responsible for the development of corn cob fusariosis and root rot and basal stem rot whose perpetrators can produce mycotoxins.

In addition to the species mentioned above, there are many other pests that threaten maize plantations to a greater or lesser extent. In recent years, we have seen an increase in the occurrence of four-spotted sap beetles, cereal leaf beetles, red spider mites, maize leafhoppers, leaf roller moths, meadow froghoppers, lygus bugs, owlet moths and, locally, cotton bollworms. Other local pests include turnip maggots, seedcorn maggots, grubs, birds and game. There are also entirely new threats, such as a leafhopper of the species *Cicadula Placida*. Several species of snails can be found in sweetcorn crops, such as the grey field slug, European red slug and Iberian slug, as well as rodents and a variety of other plant-eating pests. This is why it is so important to keep an eye on the crop and be able to identify the species that appear.

The list of selected phytophages occurring in maize crops and their current relevance is given in Table 3.

Table 3. Economic importance of selected sweetcorn phytophages

Name of herbivore	Current economic importance
Elm sack gall aphid (*Tetraunera ulmi*)	+
Red sword-grass moth (*Xylena vetusta*)	+
Silver Y (*Plusia gamma*)	+
Click beetles (Elateridae)	+ (+)
Rodents (Rodentia)	+
Bishop’s Mitre (*Aelia acuminata*)	+
Leafhoppers (Bibionidae)	+
Corn ground beetle (*Zabrus tenebrioides*)	+
Aphids (Aphididae)	++ (+)

Leaf miners (Agromyzidae)	+
European corn borer (*Ostrinia nubilalis*)	++ (+)
Crescent (*Helotropha leucostigma*)	+
Great green bush-cricket (*Tettigonia virdissima*)	+
Flea beetles (Halticinae)	+
Grubs (Melolonthinae)	+
Owlet moths (Hadeninae)	+
Frit fly (*Oscinella frit*)	++ (+)
Grass fly (*Elachiptera cornuta*)	+
Sloe bug (*Dolycoris* baccarum)	+
Red spider mite (*Tetranychus urticae*)	+
Birds (Aves)	+ (+)
Cutworm (Agrotinae)	+
Cereal leaf beetles (Oulema spp.)	+
Colorado corn rootworm (*Diabrotica virgifera virgifera*)	+ (+)
Leafhopper (*Macrosteles laevis*)	+
Maize leafhopper (*Zyginidia scutellaris*)	+
Cotton bollworm (*Helicoverpa armigera*)	+
Turnip maggot (*Delia platura*)	+
Snails and slugs (Gastropoda)	+
Jarr worm (*Gryllotalpa gryllotalpa*)	+
Four-spotted sap beetle (*Glischrochilus quadrisignatus*)	+
Thrips (Thripidae)	++
Knot grass moth (*Acronicta rumicis*)	+
Myriapods (Myriapoda)	+
Reed dagger (*Simyra albovenosa*)	+
Dock bug (*Coreus marginatus*)	+
Bishop bug (*Lygus rugulipennis*)	+
Vapourer moth (*Orgyia antiqua*)	+
Tortrix moths (Tortricidae)	+
Game (Mammalia)	++
Tortoise bug (*Eurygaster maura*)	+

+ small; ++ medium, +++ large

7.3.2. Methods of monitoring pests in maize cultivation

In integrated pest management, it is extremely important to monitor for the emergence of pest species (including their individual stages) to determine the need for and timing of control. The results of the observations must be recorded in order to document the validity of the subsequent use of chemical pesticides. Observing maize plants for the presence of pests is key to detecting the threat and responding appropriately. Monitoring should cover the period from the time the field is selected for sowing (soil analysis for pests) to harvest.

Monitoring of the prevalence and abundance of pest species should be carried out at least weekly and, in the case of very economically important species, 2-3 times a week during the period when the date for their eradication is set. In Table 4. The most important methods for determining the number and harmfulness of selected pests are presented. It should be borne in mind that even where different catch pots are used, their recommended number per unit area may be set from the top down by their manufacturers. In addition, some traps, catch pots or sticky boards are recommended for use only on the edge of the crop – so they do not need to be placed deep in the crop, reducing the number of tools needed. However, the number of traps required for observation should be discussed with the manufacturer or distributor.

Table 4. Methods of observation to determine the timing and need for control of selected sweetcorn pests

Pest	Date of analysis	Method of observation
Wireworms	before sowing (BBCH 00)	sift soil from 25 x 25 cm holes 30 cm deep. Make at least 32 soil pits at equal intervals per 1 hectare of maize crop. With each subsequent hectare, the number of pits should be increased by 2. Determine the number of wireworms.
	From sowing to full grain maturity (BBCH 00–89)	place pheromone traps, including Yatlorf type with a pheromone dispenser designed to catch a specific species of spring beetle, on the balk around the maize plantation. The recommended number of traps per area is indicated by their manufacturers. The trap enables determination of the level of click beetle abundance in a given area.
Bibionidae (march flies)	before sowing (BBCH 00)	sift soil from 25 x 25 cm holes 10 cm deep. Make at least 32 soil pits at equal intervals per 1 hectare of maize crop. With each subsequent hectare, the number of pits should be increased by 2. Determine the number of bibionidae.
Aphids	from the 1 leaf stage to the end of the maize growing season (BBCH 11–97)	the average number of aphids per plant in a 1 ha plantation is determined by estimating the number of all live individuals once a week on 10 randomly selected plants diagonally across the field. Discovering an average of 300 aphids per plant indicates the need for a chemical treatment.
European corn borer	from autumn to spring (after harvest)	collect at least 50-100 fragments of maize stems with overwintering caterpillars from crop residues (visible holes) and place in an entomological insulator maintained under field conditions. From spring onwards, the emergence of the butterflies from their chrysalises is tracked, looking for the peak in the number of butterflies. Once the butterflies are found in large numbers, observations of the emergence of the pest are transferred to the maize field.
	The stem development phase to the first kernel development phase (BBCH 33–73)	monitoring plantations for the presence of moths should be carried out from mid-June. Place pheromone or light traps in the area of sowing and check at least 1-2 times a week. Observations may be intensified during pest control periods. The number of pheromone traps per unit area is indicated by their manufacturers. It is usually recommended to use 1-2 units per 1 ha. Pheromone traps are not placed deep in the seedbed. A light trap is usually sufficient at a rate of 1 per large field unless specified otherwise by the manufacturer. It is placed right next to the maize field. The discovery of the first butterflies is a signal to start biological control of the eggs, and numerous and massive imago raids indicate the need for biological or chemical treatment of the hatching caterpillars.
	From the stem	observe for the presence of egg deposition by inspecting

	development phase to the first kernel development phase (BBCH 33–73)	at least 50 consecutive plants per row at 4 diagonal locations in the plantation (200 plants in total) 1-2 times per week from mid-June. The detection of the first deposits is the signal for the immediate administration of the biopreparation to combat the eggs. The presence of large numbers of eggs indicates the need for biological or chemical control of hatching caterpillars within 4 to 10 days. A good solution is to mark the analysed plants containing pest eggs and observe their development regularly - checking when the empty shells, indicating hatching, appear.
Grubs	before sowing (BBCH 00)	sift soil from 25 x 25 cm holes 30 cm deep. Make at least 32 soil pits at equal intervals per 1 hectare of maize crop. With each subsequent hectare, the number of pits should be increased by 2. Determine the number of grubs.
Owlet moths	from milk to full grain maturity of caryopses (BBCH 73–85)	inspect 50 consecutive plants and cobs at 4 plantation sites diagonally across the field (200 plants in total) for caterpillars.
Frit fly	stage of 1-3 leaves (BBCH 11–13)	observations for the presence of eggs are made in April or May by analysing 5 plants in 10 diagonal plantations (50 plants in total). The analysis is performed 1-2 times a week. If 5 or more eggs are found on 10 plants, a plant protection treatment is justified. Monitor fly infestation using yellow, white or purple vessels filled with water and detergent set up in the marginal strip at a frequency of 1-2 per hectare. The use of yellow sticky boards at a frequency of 1-2 per 1 ha has a similar effect. When using traps and boards, there is no need to place them deep in the field – the pest flies in from the outside.
	Stage of 8-9 leaves (BBCH 18–19)	in order to calculate the percentage of damaged plants, a minimum of 50 consecutive plants per row in four parts of the plantation (200 plants in total) should be inspected over an area of 1 ha.
Cutworms	before sowing (BBCH 00)	sift soil from 100 x 100 cm holes 30 cm deep. Make at least 2 soil pits at equal intervals per 1 hectare of maize crop. With each hectare, the number of open pits should be increased by 2 with dimensions of 25 x 25 cm and a depth of 30 cm. Determine the number of cutworms.
	From 3-9 leaves to dough (BBCH 13–85)	place pheromone traps in the marginal strips of the sown field to monitor the butterfly infestation of individual cutworm species. The number of recommended traps shall be indicated by the manufacturer. Typically, 1-2 pheromone traps for a particular species of cutworm (usually dominated by turnip moth) are placed in an area of 1 ha and checked at least once a week. A significant increase in butterfly numbers indicates the risk of caterpillar occurrence.
	From 3-9 leaves to the 2-3 nodes (BBCH 13-19 to 32-33)	within an area of 1 ha, inspect 50 consecutive plants at 4 plantation sites diagonally across the field (200 plants in total) for caterpillars.

	From early milky to dough (BBCH 73–85)	within an area of 1 ha, inspect 50 consecutive plants and cobs at 4 plantation sites diagonally across the field (200 plants in total) for caterpillars.
Colorado corn rootworm	From the end of June to mid-July (BBCH 32–59)	If the crop is a monoculture (not recommended in IP because it favours the development of the pest), the number of larvae can be determined during the bending period of the stems by feeding at least 10 roots with the surrounding soil in five diagonal plantings (50 plants in total). Assess the presence of larvae and the extent of root damage.
	From the 3rd leaf collar stage to kernel milk stage (BBCH 32–79)	in determine the number of beetles per hectare of crop, it is best to set 1-2 pheromone traps at a distance of at least 50 metres from the edge of the plantation. The recommended number of traps per unit area may be specified by the manufacturer. Check traps 1-2 times a week, starting from July to August. A significant increase in the number of beetles harvested is a signal to carry out the control procedure. The presence of beetles can also be detected by light green stickers placed on plants at a rate of 1-2 per hectare from the edge of the field.
Other species	from sowing to harvest (BBCH 00–99)	in order to detect the abundance and harmfulness of aboveground pest species in an area of 1 ha, 100 consecutive plants per row should be inspected at least once a week at four points in the plantation (diagonally). Non-selective yellow sticky boards will also be helpful as well as blue ones for thrips detection for monitoring. They are applied at a rate of 1-2 units per hectare from the edge of the field.

As soon as economically important pests are detected, the decision to carry out a chemical treatment should be made on the basis of commercial threat thresholds. The harmfulness threshold is the severity of the pest at which the value of the expected loss in the yield is higher than the total costs of treatment.

Commercial threat thresholds relating to pests are one of the most important and, at the same time, most difficult to determine aspects of chemical plant protection. Harmfulness threshold values may not be treated unambiguously. Depending on the stage of plant development, climatic conditions or the occurrence of natural enemies, the value of the threshold may change. The commercial threat thresholds only serve as an aid in decision making, but cannot be the only criterion to be taken into account as the corn grower's years of experience and practical knowledge are equally important.

The current economic damage thresholds apply to both feed maize (normal) and sweet maize (Tab. 5).

Table 5. Economic thresholds for sweetcorn

Pest	Observation date	Harmfulness threshold
Wireworms	before sowing (BBCH 00)	2-8 larvae per 1 m^2 of the field
Bibionidae (march flies)	after emergence (from BBCH 10 onwards)	10 larvae per 1 m^2 of the field
Aphids	from tassel (BBCH 51)	300 aphids on 1 plant

European corn borer	tassel stage (BBCH 51-59)	6-8 egg deposits per 100 plants or when 15% of grain maize plants or 30-40% of silage and CCM plants were damaged in the previous year
Frit fly	from emergence to 4 leaves (BBCH 10–14)	damage to 15% of plants in the previous year
Cutworms	emergence (BBCH 10-14)	1 caterpillar per 2 m^2 of the field
	5-6 leaves (BBCH 15-16)	1-2 caterpillars after the 3rd exuviae per 1 m^2 of crop

7.3.3. Non-chemical pest control methods

Breeding method

For non-chemical methods of reducing damage from certain phytophages, buying certified corn seed from a known source is particularly important. If there are varieties on the market that are less susceptible to certain pests, e.g. European corn borer, it is worth using them if there is a pest problem at the place of production.

Agrotechnological method

In non-chemical methods of reducing phytophagous infestations and damage, as in the case of pathogens, an important consideration is the selection of the optimum growing site to ensure proper plant development. The optimum conditions for sweetcorn development are described in Chapter 3.

Many phytophages overwinter in the soil, and some in maize residues, so it is very important to use crop rotation and very careful post-harvest residue shredding, preferably mixing it with the soil layer for faster dispersal. For phytosanitary reasons, a break of at least 3-5 years is recommended between sweetcorn crops on the same site.

It is also important, where technically possible, to isolate this vegetable crop from fodder maize crops to avoid pollination of the plants (which is undesirable in terms of yield quality) and easy movement of pests between fields.

The degree of threat from many pests can be influenced by certain agrotechnical treatments. Optimal fertilisation, particularly with nitrogen, is one of them. Plants that are properly fertilised, taking into account the fertility of the site and their nutritional requirements, can be less susceptible to stresses that increase their susceptibility to damage from pests. The use of nitrogen in excessively high doses contributes to an increase in the damage of plants by the European corn borer.

It is advisable to sow maize as early as possible, but in a sufficiently warmed soil so that the plants are more advanced in development when the spring species appear. The date of sowing should take into account the thermal requirements of the crop and the agrotechnological recommendations for that vegetable, including the production conditions associated with the systematic supply of commercial crops to the market.

Weed control is also important as some weeds can provide overwintering or predevelopment sites for certain pests such as European corn borer, aphids, thrips, red spider mite and others.

To reduce the quantity and quality of grain lost to pests, the cob crop should be harvested in good time. Harvesting can be done in stages, depending on the sowing date, the earliness of the variety and the maturity of the kernels in the cobs.

A list of the most important non-chemical methods for reducing the infestation and damage caused by sweet corn phytophages is given in Table 6.

Table 6. Non-chemical methods to protect sweetcorn from selected phytophages

Herbivore	Ways of reducing harmfulness
Red sword-grass moth	correct agrotechnology, weed control, spatial isolation (from wetlands and main host plants, e.g. great water dock, cornflower, true sedges, irises, knotweeds),
Silver Y	correct agrotechnology, control of amaranth family weeds, spatial isolation (from other host plants, e.g. brassica vegetables, rapeseed, beet, potatoes), crop residue shredding, winter ploughing (traditional system)
Helotropha leucostigma	correct agrotechnology, weed control, spatial isolation (from wetlands and main host plants, e.g. sweet flag, true sedges, bur-reed, irises),
Wireworms and grubs	correct agrotechnology, crop rotation, shallow tilling, discing, harrowing, selection of cultivars with extensive root systems and rapid initial growth, early sowing, increased sowing, soil loosening, weed control, spatial isolation (from wasteland, meadows, pastures and forests), crop residue shredding, winter ploughing (traditional system).
Rodents	correct agrotechnology, crop rotation, shallow tilling, discing, harrowing, soil loosening, weed control, mowing of grasses around the plantation, spatial isolation (from uncultivated land, meadows, pastures and cereals), winter ploughing (traditional system).
Bibionidae (march flies)	correct agrotechnology, crop rotation, ploughing, spatial isolation (from wetlands and cereal crops), early sowing, increased sowing standard,
Leaf miners	correct agrotechnology, sustainable fertilisation (from cereal crops, permanently uncultivated green land), weed control,
Aphids	correct agrotechnology, sustainable fertilisation (mainly with nitrogen), spatial isolation (from host plants such as maize, cereals, bird cherry, wild and garden roses, elm, meadows, pastures, waste land), early sowing, weed control, protection of beneficial insects,
European corn borer	correct agrotechnology, crop rotation, selection of cultivars less susceptible to pests, shallow tilling, discing, balanced fertilisation (especially with nitrogen), spatial isolation (from other maize fields, maize residues and other host plants, e.g. fodder maize, hops, millet), use of biopreparations, early harvesting, crop residue shredding immediately after harvesting, winter ploughing (traditional system)
Great green bush-cricket	spatial isolation (from meadows, pastures, waste land), weed control,
Flea beetles	correct agrotechnology, sustainable fertilisation, early sowing, spatial isolation (from brassica vegetables, oilseed rape, beet, cereals), weed control,
Meadow froghopper	spatial isolation (from wetlands, meadows, pastures, waste land), sustainable fertilisation, weed control,
Hadeninae and cutworms	correct agrotechnology, crop rotation, shallow tilling, discing, spatial insulation (from brassica vegetables, rapeseed, wasteland, cereals, wetlands), balanced fertilisation, selection of varieties with an extensive root system, early sowing, increasing the standard of sowing, control of weeds, crop residue shredding, winter ploughing (traditional system)
Grass fly	correct agrotechnology, sustainable fertilisation, early sowing, weed control, spatial isolation (from winter cereals, meadows, pastures),

Frit fly	correct agrotechnology, shallow tillage, early sowing, weed control, cultivation of less susceptible varieties, in high-risk areas – cultivation of varieties with fast initial growth, spatial isolation (from winter cereals, meadows, pastures),
Red spider mite	correct agrotechnology, crop rotation, weed control,
Birds	early sowing, increased sowing standard, spatial isolation (from larger forest stands), use of acoustic and light deterrents,
Cereal leaf beetle	correct agrotechnology, early sowing, spatial isolation (from cereal crops), sustainable fertilisation,
Leafhopper Maize leafhopper	correct agrotechnology, early sowing, spatial isolation (from cereal crops), sustainable fertilisation,
Cotton bollworm	correct agrotechnology, crop rotation, control of weeds, use of biopreparations, crop residue shredding, winter ploughing (traditional system)
Colorado corn rootworm	correct agrotechnology, crop rotation, selection of cultivars with an extensive root system, spatial isolation (from monoculture maize), early sowing, control of weeds, use of biopreparations, crop residue shredding, winter ploughing (traditional system)
Snails and slugs	correct agrotechnology, crop rotation, shallow tilling, discing, careful tillage, soil liming, spatial insulation (from cereals, rapeseed and brassica vegetables), early and deeper seed sowing, increasing the standard of sowing, controlling weeds, clearing grasses around plantations, crushing crop residues, winter ploughing (traditional system)
Turnip maggot	correct agrotechnology, crop rotation, selection of cultivars with rapid initial growth, early sowing, increasing the norm of grain sowing, weed control, accurate manure spreading, crop residue shredding, winter ploughing (traditional system)
Jarr worm	correct agrotechnology, crop rotation, weed control, mowing of grasses around plantations, spatial isolation (from wetlands, orchards, forests and vegetable crops), crop residue shredding, winter ploughing (traditional system)
Four-spotted sap beetle	correct agrotechnology, crop rotation, spatial isolation (from orchards and vegetable crops), timely harvesting, crop residue shredding, winter ploughing (traditional system)
Thrips	correct agrotechnology, early sowing, spatial insulation (from cereal plants, wasteland and meadows), balanced fertilisation, weed control
Knot grass moth	correct agrotechnology, crop rotation, spatial isolation (from meadows, forests, mid-field woodlands and wetlands), weed control,
Reed dagger	correct agrotechnology, crop rotation, spatial isolation (from meadows, forests, mid-field woodlands and wetlands), weed control,
Lygus pratensis	correct agrotechnology, crop rotation, balanced fertilisation, spatial isolation (from meadows, pastures and uncultivated land), cultivation of varieties with compact husk leaves, weed control, timely harvesting
Vapourer moth	spatial isolation (from larger deciduous and coniferous forest stands),
Game	early sowing, increasing seeding standards, spatial insulation (from larger stands), use of acoustic, light and repellent repellents, construction of permanent fences, crop residue shredding and covering with soil
Leafroller moths	correct agrotechnology, spatial isolation (from cereal crops), sustainable fertilisation (especially with nitrogen), weed control,
Other species	correct agrotechnology, crop rotation, plant care, crop residue shredding

7.3.4. Chemical pest control methods

It should be borne in mind that hat in integrated production (IP) of sweetcorn, only zoocides recommended for (IP) vegetable crops may be used to include this maize subspecies.

Plant protection products against pests should be used in accordance with the current programme for the protection of sweetcorn in integrated production (IP) based on the monitoring of their occurrence. Messages from the Online Pest Warning System (www.agrofagi.com.pl) may be helpful. The use of plant protection products must be in accordance with the information on the label. A tool to assist in the selection of an active ingredient can be the plant protection product search engine and up-to-date information on the use of plant protection products, which can be found on the website of the Ministry of Agriculture and Rural Development at the following address https://www.gov.pl/web/rolnictwo/ochrona-roslin. Detailed information on registered plant protection products for the protection of sweetcorn can be found at the link https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie. The list of measures approved for integrated production is available at https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji

Based on the selection of chemical pests, the prevention of resistance to insecticides should be considered, taking into account their rotation with different mechanisms of action according to the IRAC classification or belonging to different chemical groups.

7.3.5. Reducing damage caused by wild game and birds

Protection of maize crops from wild boars and deer

The protection of sweetcorn crops from wild boar and deer in the integrated production technology of this crop should start with the correct choice of sowing site. Places that border on forest complexes where there is a large population of wild boar and deer should be avoided. Where possible, use fencing that makes it difficult for ungulates to enter the crop. As far as possible, a system of monoculture and sowing maize after maize should be avoided, as such fields are more likely to provide food for wild boar and deer that remember and are accustomed to foraging areas.

Fungicide and insecticide treatments applied to maize grain do not protect the seed from wild boar feeding. In the case of a seed treatment based on the active ingredient carbamate (Ziram), certain restrictions on feeding to wild boar and birds during maize sowing have been observed, but this has been qualified for substitution. The active ingredients in other repellents also have limited effectiveness in deterring these animals. Fragrance repellents have a very short-term effect. The mechanical method remains – the use of fences, electric shepherds, sound devices and light interacting devices. Damage can also be reduced by placing feed belts, leaving fragments of maize fields in places that are attractive to these animals, and giving the animals peace in these places by excluding them from hunting. Wild boars that have attractive and readily available food within a feeding strip or leftover part of a maize field will not be interested in the remaining areas of the field where food is difficult to access or where they are visible to a potential enemy. The methods for reducing damage should be consulted with the manager or tenant of the hunting region on whose territory the maize is grown, since the legal obligation to protect agricultural crops from wild game lies with hunting circles or Animal Breeding Centres.

The protection of sweetcorn plantations against deer is mainly based on the use of mechanical devices – fences and acoustic devices. As with wild boar, the protection of plantations should be consulted and outsourced to the tenants and managers of the hunting area in which the plantation is located. When it comes to protecting sweetcorn and other agricultural crops, shaping the agricultural environment is very important. Increasing biodiversity by planting forests, shrubs, leaving mid-fields, buffer zones between forest and agricultural areas, protecting wetlands, ponds and watercourses helps to reduce hunting damage. In this area, it is possible to receive subsidies based on agri-environmental programmes and the Rural Development Programme 2021-2027. Each year, electronic devices – photo cameras, video cameras, drones and other devices that can be remotely controlled or programmed to produce odours, sounds or visual effects – play an increasingly important role in monitoring and protecting maize crops from animal damage.

Protection of sweetcorn crops from birds

Both chemical and mechanical methods are recommended to protect sweetcorn seed from birds during the emergence period. Repellent chemicals mainly include fragrance or flavour repellents. Mechanical devices mainly include pyrotechnic devices (e.g. banger ropes, gas cannons) or electronic devices that produce predatory sounds or flashes of light. Hail nets can be used on smaller areas of sweetcorn.

The effectiveness of physical methods to prevent crop damage diminishes from year to year and fails completely in large crops. What stands in the way is the bird's intelligence and ability to learn in a focused way. The learning process of these animals, called habituation in ethology, involves ignoring a repetitive stimulus that has no biological or physical significance to the animal. Memorising and learning in birds is different from the genetically determined instinct of these animals. However, even instinctive behaviour can be modified as a result of individual experience. After a period of caution against the fear stimulus, the animals quickly get used to it and ignore it. An animal that has lost its fear of a physical stimulus in its individual life acquires permanent immunity. Proof of this can be seen in the cranes, rooks, jackdaws, pigeons, starlings, wild ducks, wild geese and other bird species that feed quietly near the settlements. Some individuals have completely lost anthropophobia.

Current toxicological and environmental requirements in the European Union limit the choice of active ingredients used in repellents and seed treatments to those that are harmless to higher animals and to the environment. Seed treatments, fungicides and insecticides, which protect the germinating plant mainly against fungal diseases and insects, are currently registered for use in maize protection. One active ingredient remained for bird deterrence – ziram.

In view of the growing problem, it is very important to carry out research into the development of new seed treatments that are safe for birds and the environment due to their properties, while at the same time having a repellent effect by acting specifically on their senses. Agriculture, and in particular maize growers in Poland and around the world, are waiting for such seed treatments.

8. BIOLOGICAL METHODS IN INTEGRATED MAIZE PROTECTION

Biological methods involve the use of natural, beneficial biological agents such as viruses, bacteria, fungi, nematodes and entomophages (parasitic and predatory insects) to reduce populations of agrophages (pests, plant pathogens and weeds) under field and shelter conditions.

Biological methods are, in most cases, slower in terms of speed than classical chemical protection. This is influenced by a number of factors, including environmental conditions, but also the biology itself and the mechanism of action of the biological agent on the reduced pest species. Biological methods may be interventionist in nature, but in most cases they act as a preventative measure, reducing the development of pest species. At least one treatment with biological pesticides to control pests or diseases is mandatory in sweetcorn production.

There are three main methods of biological pest control:

- **classic method** (introduction), in which natural enemies are introduced into new areas from other regions or continents;
- **conservation method** that consists of the protection of beneficial organisms by making changes to the environment that are beneficial to them and by the use of selective plant protection products;
- **augmentative method** in which natural enemies of a particular agrophage are introduced on a regular basis into crops where the pest is not present or is present only in small numbers.

In biological protection, it is important to plan treatments correctly depending on what is happening in a particular area. Monitoring the outbreak of the pest, including historical knowledge of the phytosanitary status of the crop from previous seasons, allows the biological protection of maize to be planned accordingly.

Reducing pest populations in sweetcorn with bioinsecticides

In sweetcorn it is possible to use bioinsecticides containing both micro-organisms (registered as biopesticides) and macro-organisms (not requiring registration). The list of registered microbiological biopreparations should be checked each time before the product is used, e.g. using a crop protection search engine: https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie

In sweetcorn crops, the most important pest is the European corn borer. In sweetcorn, a bioinsecticide containing the insecticidal bacterium *Bacillus thuringiensis* subsp. *kurstaki* strain EG 2348 is registered for control of this pest, while another strain of this bacterium, ABTS 351, is registered for control of leaf-damaging caterpillars (e.g. cutworm, European corn borer, leafroller moth). The death of an insect occurs after the ingestion of spores and toxic bacterial crystals that cause damage to the epithelial cells of the intestine. The digestive tract is paralysed and the insect stops feeding. The most sensitive are the younger larval stages of insects.

A biological product containing the insecticidal fungus *Beauveria bassiana* strain ATCC 74040 has been registered for the reduction of thrips, red spider mite and wireworm populations, which is applied by spraying the plants/soil. The infective stage of the fungus is the spores, which need to reach the surface of the pest's body. Then, given the right conditions (temperature > 20°C and high humidity), they germinate and penetrate its interior. The insect dies from paralysis caused by the overgrowth of its body by the developing fungal hyphae. All stages of pest development are vulnerable. One of the symptoms of fungal infestation is mummification, the body of the pest is hard and on its surface a mycelium of different colours is formed along with spores.

When using biopreparations containing micro-organisms, it is essential to monitor the presence of pests in order to determine the optimum time for their eradication, including the number of treatments required to effectively reduce their population as indicated on the label of the product.

When using micro-organisms to control sweetcorn pests, please note that:

- are sensitive to high temperatures and strong sunlight (including UV radiation);
- the bacteria are best used when the first caterpillars/larvae of the pest appear, as the younger stages of the pest are more sensitive to insecticidal bacteria;
- insecticidal fungi in their first stage of action require temperatures of around 25^{0}C and high humidity to germinate and enter the insect;
- pest caterpillars do not die until 24-72 hours after eating fungal spores. During this time, they can feed and look healthy,
- micro-organisms are applied using self-propelled or tractor-mounted sprayers. Such treatments should preferably be carried out in the evening or early morning,
- chemical fungicides must not be used after the use of biological agents containing micro-organisms;
- they are living organisms and have a short shelf life at room temperature, but can be stored in the refrigerator for up to 6 months.

A macro-organism is registered for the biological control of the European corn borer, a parasitic Hymenoptera called (*Trichogramma* ssp.). Biopreparations containing various species of this Hymenoptera are available on the market, with *Trichogramma brassicae* being the most commonly used in Poland. Trichogramma wasps are oophages, i.e. they parasitise the eggs of various insects and develop inside them. Biopreparations containing Trichogramma wasps are not subject to registration in Poland. In maize, the Trichogramma wasp is used to reduce the eggs of the European corn borer, but indirectly it can also reduce the eggs of other butterfly pests that occur at this time, such as the cutworm, owlet moth and cotton bollworm. Female Trichogramma wasps lay their eggs to the freshly laid eggs of the European corn borer. After hatching, their larvae destroy the host egg as they develop, changing the colour from white to black. The effect of the treatment is that the caterpillars of the pest do not hatch. The Trichogramma larva pupates inside the host egg, after which a new generation of Hymenoptera emerges and the developmental cycle repeats. When using a biopreparation with Trichogramma wasps, monitoring for European corn borer infestation or observing the appearance of the first eggs on the plants to determine the timing of the application is critical to its effectiveness.

There are several techniques for applying biopreparation containing Trichogramma wasps:

- Cardboard tags with Trichogramma wasps are attached to the leaves or stems. Inside are larvae and pupae of Trichogramma wasps, which develop over a few days to emerge as adult insects;

- a product containing trichogramma can be in the form of biodegradable pellets containing a carrier with the entomophage, which can be spread over the maize field by hand or using a drone or autogyro.
- the biopreparation can be loose and can be applied to plants and soil using a special applicator and a drone or autogyro.

A biopreparation containing live Hymenoptera is produced to order. It cannot be stored for long. Transport is in a refrigerated container. It should be laid out immediately on receipt, failing which it can be stored in a cool, dark place for a maximum of 1-2 days after delivery.

In the spring, biopreparations containing insecticidal nematodes of the species *Heterorhabditis bacteriophora* (a non-registrable macro-organism) may be applied topically to crops threatened by corn rootworm larvae feeding in the soil on maize roots. They are used in maize drilling after the use of modified seed drills where the nozzles of the mounted sprayer are placed directly behind the soil cutting knife. This allows the nematodes to be precisely introduced into the soil in the immediate vicinity of the seed. In a moist soil environment, the nematode independently seeks out corn rootworm larvae to parasitise, releases symbiotic bacteria with insecticidal activity and then reproduces in the host, which later leaves in search of another victim.

In integrated production, the method of biological control of slugs using a biopreparation containing infective forms of the nematode species *Phasmarhabditis hermaphrodita* (a macro-organism not subject to registration) can also be used. The formulation is applied as a spray on plants and soil. Nematode larvae enter the slug's body through the respiratory tract, infecting it with bacteria and causing it to stop feeding after 3-5 days. The application of the agent to a moist substrate increases its effectiveness. The preparation remains in the soil for about six weeks. When using preparations containing nematodes, it is important to know that the sprayer should have nozzles larger than 0.5 mm and the pressure should not exceed 20 psi. The preparation contains living organisms – larvae of nematodes, so they must be used with particular care and according to the product label.

Reduction of pathogens in sweetcorn using biofungicides

In view of the changing market for biopreparations to reduce plant diseases in Poland, information on the availability of specific biopesticides registered to reduce the population of pathogens in sweetcorn sowings should be continuously monitored.

Biofungicides registered in Poland include species of parasitic fungi such as: *Pythium oligandrum*, Coniothyrium minitans i *Gliocladium catenulatum* as well as antagonistic fungi of the genus *Trichoderma* e.g. *Trichoderma asperellum*. These are parasitic fungi, which can be found in the soil environment under natural conditions and are important in reducing disease pathogens.

It is important to bear in mind that it is not possible to ensure the complete protection of maize with the exclusive use of biological agents. However, they complement the chemical method of protection by effectively reducing its level.

Conservation biological control

In reducing sweetcorn pests, it is also important to protect their natural enemies, which can reduce the populations of various pests in the environment. Beneficial organisms active in the environment include predatory beetles such as ground beetles, rove beetles and ladybirds; parasitic flies (e.g. tachinid flies) and Hymenoptera (e.g. aphid wasps and ichneumon wasps); predatory flies (e.g. flower flies and ground beetles); predatory true bugs and lacewings; and many others that provide natural resistance in the environment.

In the soil environment, various species of insecticidal fungi can act in favourable conditions to reduce grubs, for example. These are: *Beauveria bassiana*, *B. brongniartii*, *Cordyceps fumosorosea*, *C. farinosa* i *Metarhizium anisopliae*. Aphids on leaves can be infected by insecticidal fungi of the *Entomophthoraceae* family. When temperatures and humidity are high, they often cause epizootics, i.e. mass dieback of maize aphid colonies (cherry-oat aphid and rose-grass aphid). That is why it is so important to carry out treatments that have a beneficial effect on the growth of biodiversity in the natural environment of arable fields.

Activities that support the effectiveness of biological agents in the environment:

- leaving dead furrows, thickets, shrubs and mid-field refuges that support the development of the beneficial insects and micro-organisms that live there;
- forest surroundings are a refuge for beneficial insects and micro-organisms (e.g. insecticidal fungi);
- sowing honey-bearing plants and creating flowering strips in crops;
- according to the List of Obligatory Measures, suitable conditions must be created for the presence of birds of prey, i.e. resting poles must be provided at a rate of at least 1 per 10 ha, or several in the case of larger plantations.

Plant protection products, including biological products, should be used in the crops in which they are recommended for use and the information for use contained on the label should be observed. The basis for their application is the monitoring of harmful species.

The list of plant protection products authorised in Poland, including microbial biopesticides, is published in the Register of Plant Protection Products. Information on the extent of biopesticide use in individual crops is included on the labels. The plant protection product search engine is a helpful tool when selecting pesticides. Current information on plant protection products use is available on the Ministry of Agriculture and Rural Development website at https://www.gov.pl/web/rolnictwo/ochrona-roslin.

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

9. PROTECTION OF USEFUL ENTOMOFAUNA FOUND IN MAIZE PLANTATIONS

Protection of bees and other pollinators

As a monoecious and wind-pollinated crop, maize is not directly dependent on pollinating insects. However, wild pollinators, including honeybees, may be present in its crops. During the flowering period of maize, pollen-collecting workers may appear. This usually occurs when the bees, while flying to a better feeding location, encounter maize plantations. In addition, the European honey bee and other beneficial insects can be found on maize leaves covered with aphid honeydew. It is also important to remember that mass flowering weeds in but also near the crop attract significant numbers of pollinators. Therefore, while caring for the agricultural environment as a whole and its biodiversity, this should also be taken into account when applying chemical protection to plants that are not pollinated by insects.

In view of the obligation to protect crops in accordance with the principles of integrated pest management, consideration should be given to the selection of plant protection products in a way that minimises the negative impact of plant protection treatments on non-target organisms, in particular pollinators and natural enemies of harmful organisms.

More effective use of beneficial species can be achieved by taking a number of measures that include:

- rational use of chemical plant protection products and basing decisions on the real risk to the maize crop from pests, assessed on an ongoing basis. One should consider abandoning treatments if the occurrence of the pest is not numerous and is accompanied by the occurrence of beneficial species. In this group of activities, the limitation of the treatment area to treatments on edges and in patches should be considered if the pest does not occur on the whole plantation. It is recommended to use tested mixtures of plant protection products and liquid fertilisers in order to limit the number of visits to the field and mechanical damage to plants;
- protection of beneficial species by avoiding the use of insecticides with a broad spectrum of activity and replacing them with selective agents;
- choosing the treatment time to prevent high mortality among beneficial insects;
- based on the results of the study, reducing doses of the products and adding adjuvants;
- constant awareness that protecting natural enemies of maize pests also protects other beneficial species present in the field;
- leaving balks and mid-field shelters as a habitat for many species of beneficial insects;
- carefully reading the label attached to each plant protection product and observing the information contained therein.

Natural enemies are most often not able to continuously reduce the number of pests to levels below commercial threat thresholds. However, it should be remembered that integrated cultivation technologies whose basic element is integrated protection against pests, require producers to provide rational protection based on the greatest possible use of useful activity of parasites and predators.

In addition to honeybees, other insects are very efficient pollinators. In order to ensure the development of wild pollinators in agrocenoses and thus increase pollination efficiency, houses for mason bees or mounds for bumblebees (1 pc. for every 5 hectares of plantation) should be placed within the growing area.

Protection of biodiversity and beneficial species

In arable crops, including maize, the main method of conservation is beneficial use, i.e. the use of landscape elements in agricultural and forest areas that enable and promote the development of the population of naturally occurring beneficial organisms. The main aim of the measures taken is to improve habitat quality for these organisms by diversifying the landscape, creating hiding places and suitable overwintering sites, and securing a feeding base for naturally occurring enemies of agrophages. The rational use of selective chemicals to reduce their negative impact on beneficial organisms is also a very important part of this strategy.

Maize fields provide good habitats and growth conditions for many insect species. Many species of parasitic and predatory insects live in the crops as well as on the balks which assist farmers in reducing herbivore abundance. High plant species diversity in agroecosystems is important. In addition, the creation of vast fields and the removal of agriculturally unproductive thickets and mid-field shrubs is reducing the natural plant communities that provide habitats for beneficial insects. They are an important part of the natural resistance of the environment to pest gradation. Therefore, it is important to observe not only pests in cultivated fields, but also their natural enemies, whose role is very often underestimated. Hence, these allies are worth getting to know well in order to prevent their careless destruction. Within the relationships occurring between a pest and its natural enemy, predation – where a predator is an organism that kills and eats individuals of another species (predator-prey system) – is one important factor. The second form of coexistence between two organisms is parasitism, where one benefits from the coexistence and the other suffers harm from it.

Predatory beetles

One of the most important groups of predators found in the agroecosystem are ground beetles because, being non-specialised predators, they fulfil an important role as natural enemies of plant pests. Of great importance are predatory insects of the (Carabidae) family. The Carabidae family is one of the more numerous groups of insects in Poland. It includes more than 500 beetle species. Most of them lead a ground-based life – on the surface and in the top layers of organic soil where they feed, reproduce, and overwinter. A distinction is made between epigeal, litter-soil, and soil Carabus beetles. Most adult insects, as well as larvae, feed at night. Their prey can include insect larvae and adults, annelids, snails and other small organisms, including predatory organisms. Carabidae prey also includes aphids, ants, butterfly caterpillars, among others, of cutworms, or larvae, immobile insect pupae, and earthworms. A factor influencing the diversity and size of Carabidae groupings is mineral and organic fertilisation. Carabidae can be an indicator of biodiversity in temperate climate phytocoenoses because of their well-studied systematics and the ease of obtaining material. In the Wielkopolska region, *Harpalus rufipes* accounted for about 50% of the groupings surveyed in fields where integrated production is applied. Other species found in the fields were: *Calathus ambiguus, Bembidion quadrimaculatum* and *Poecilus cupreus*, and *Pterostichus melanarius.*

Beetles of the rove beetle family (Staphylinidae) are also pest-reducing insects. This is the most numerous family of insects in Poland, represented by more than 1 400 species. Both larval and adult forms prey on a variety of small organisms. The most common species among *Staphylinidae* include: rove beetle (*Aleochora bilineata*), *Tachyporus hypnorum* and *Philonthus fuscipes*. They occur in a variety of environments. Species diversity of Staphylinus is much higher at the edges of forests and woodlands than in the central part. Rove beetles are thought to be poorly specialised predators, predominantly hunting incidentally, destroying eggs of insects such as the European corn borer, larvae and pupae of cereal leaf beetle, larvae of bishop bugs, and small arthropod species unprotected by a thick chitin carapace. The more numerous they are in the soil, the less chance of mass reproduction for many herbivore species. This is mainly the case for herbivores which reside in the soil in their diapausing stages, providing a good food base for carabidae and rove beetles.

Ladybirds (Coccinellidae) are very important in sweetcorn cultivation. There are 3 500 ladybirds described in the world, and more than 70 species are present in Poland. Ladybirds are natural enemies of scale insects, greenhouse whiteflies, and mites. These insects are important regulators of aphid abundance in agrocenoses. A number of factors can influence the dynamics of ladybird abundance, one of the most important being the synchronisation of the predator-prey system. The most common ladybirds in Poland include: multicoloured Asian ladybird (*Harmonia axyridis*), seven-spot ladybird (*Coccinella septempunctata*), two-spot ladybird (*Adalia bipunctata*), 14-spotted ladybird beetle (*Propylea quatuordecimpunctata*) and lesser mite destroyer (*Stethorus punctillum*). Despite the fact that the Asian ladybug is an invasive species, as an efficient predator it effectively limits colonies harmful to insect plants. Ladybird larvae of different species are capable of destroying up to 2 000 aphids during their development. Adult insects eat between 30 and even 250 of these pests per day. The larvae and adults of the spider mite (*Stethorus pusillus*) can also be found on maize leaves infested with spider mites.

In addition to the predatory beetles mentioned above, many other beetles are found on plantations, including tiger beetles (Cicindelidae), clown beetles (Histeridae) and soldier beetles (Cantharidae), which also reduce the numbers of certain pests.

Predatory and parasitic flies

Certain flies (Diptera) are important predatory insects, mainly those belonging to the flower flies (Syrphidae) and tachinid flies (Tachinidae) families. Flower fly larvae are among the most important natural enemies of aphids. The most effective action of their larvae takes place during the mass emergence of aphids. During larval development, one individual destroys between 200 and 1 000 aphids. Predators also include members of the gall midge family (Cecidomyiidae), such as the aphid midge (*Aphidoletes aphidimyza*), which, as its name suggests, is found in aphid colonies. The flies lay their eggs at the feeding site of the aphids and the legless larvae, which hatch in various colours (yellow, orange, brownish, grey), suck the contents of the aphid's body.

A huge role in natural conditions in limiting populations of many harmful insects is played by flies of the tachinid family (Tachinidae). Parasitisation of many harmful butterfly caterpillars by these hymenoptera can reach up to 60% in June. The females feed on pollen and nectar from cultivated and wild plants before they start laying eggs. Therefore, the presence of flowering plants that attract them close to agricultural land and orchards is of great practical importance for the protection of the maize and provides a food base for this parasitoid.

Predatory and parasitic Hymenoptera

Among the parasites that naturally limit the populations of aphids in maize cultivation are the hymenoptera of the aphididae family. Female parasitic wasps lay eggs singly into the body of aphid larvae that are found in the maize crop. The development of the parasitoid larva takes place entirely inside the body of the prey which dies off, and the adult form, after pupating, escapes to the outside through a hole bitten in the dorsal part of the aphid's body. Aphids lose their waxy coating, their body becomes matt and transforms into what is known as a mummy.

An example of another parasitic wasp that occurs naturally in maize plantations is the Trichogramma wasp (Trichogramma spp.), such as *Trichogramma evanescens*. Hymenopetra can parasitise the eggs of certain maize pests, particularly the European corn borer. They are not abundant, which is why biopreparations based on them are used. However, their role in nature is very important.

Parasites include braconid wasps (Braconidae), ichneumonid wasps (Ichneumonidae), aphelinid wasps (Aphelinidae) and chalcid wasps (Chalcididae), which attack the caterpillars of various butterflies, some beetles and flies.

Predatory lacewings

Representatives of net-winged insects (Neuroptera), whose larvae have sickle-shaped chews adapted to hollow out other insects, lead a predatory lifestyle. The dominant species, common green lacewing (*Chrysoperla carnea*), is particularly important in reducing the number of maize pests. Apart from aphids, larvae of green lacewings also eat eggs of other harmful insects and spider mites. In addition to the common green lacewing, a brown lacewing (*Micromus angulatus*) can also be found in aphid colonies, feeding on a variety of aphid species.

Predatory true bugs

Among the true bugs (Heteroptera), important predatory species belong to the families of capsid bugs (Miridae), minute pirate bugs (Anthocoridae) and shield bugs (Pentatomidae). They use a spike as a killing spear and then hollow out their victims. Their food includes, for example, spider mites, aphids, thrips, or butterfly eggs. In a 24-hour period, common flower bugs can hollow out 50 spider mite eggs or 7 aphid or thrips larvae. Among the Anthocoridae, the common flower bug (*Anthocoris nemorum* L.) plays a major role as a beneficial organism. Species of the damsel bugs (Nabidae) family are also important.

Predatory earwigs

In natural conditions, earwigs (Dermaptera) are also included among beneficial insects. They are polyphagous insects. They mainly lead a predatory lifestyle. They reduce the number of aphid colonies. They also eat eggs and young larvae of other species of harmful insects, e.g. owlet moths.

Predatory spiders and harvestmen

Spiders play an underestimated role in nature. In the fields there are running spiders, large web-building spiders, as well as small spiders, living and building their webs on the surface of the earth and in its crevices. Spiders are non-specialised predators, i.e. their victims are those organisms that they manage to catch. Because the spider’s diet is dominated by the prey species that is the most numerous at the moment, their importance is greatest at a time of pest infestation of the crops. Unfortunately, spiders are polyphagous, so their victims can also include beneficial insects.

Birds of prey

In reducing small mammals (rodents, hares), birds of prey living close to plantations are effective. To give them a better vantage point, resting poles of at least 3 m in height (minimum 1 per 5 ha) should be placed along the plantation.

10. PROPER SELECTION OF PLANT PROTECTION TECHNIQUES

Storage of plant protection products

Plant protection products should be stored:

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

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

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

Plant protection products in accordance with the principles of good practice should be stored in separate rooms (except residential and livestock buildings). These rooms should be clearly labelled (e.g. sign: ‘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 how to handle the specific chemical.

Requirements for professional users

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

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

Apparatus and equipment for protective treatments

The sprayer or other equipment used for crop protection must be technically efficient, ensure reliable operation and guarantee the safe use of plant protection products, liquid fertilisers or other agrochemicals. The sprayer must have an up-to-date condition test (certification) and should be properly calibrated. The equipment technical fitness is confirmed by a test report and a control mark issued by authorised bodies (Sprayer Control Stations). Testing of new equipment is carried out no later than five years after its acquisition and subsequent tests are 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 action to allow accurate dosing and even distribution of plant protection products on the treated area of the field.

Before the treatment, it is necessary to check the technical fitness of the sprayer, in particular the condition of the filters, pumps, lubrication and greasing points, sprayers, field beam, measuring and control devices, the liquid system and agitator. It is also advisable to carry out preventive rinsing of the sprayer in order to clean the system of mechanical impurities and possible residues from previously performed treatments.

Calibration (adjustment) of the sprayer

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

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

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

Choice of plant protection product and dosage

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

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

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

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

When using plant protection products, also in split doses, the requirements specified in the product label must be observed, i.e.:

- **time intervals between various treatments,**
- **maximum number of uses per season,**
- **maximum dose of plant protection product.**

Selection of volume of spray liquid

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

Contact-acting agents require very good coverage of the plants being sprayed and generally require higher volumes of spray liquid than systemic products. In foliar feeding treatments and combined application of several chemicals, increased spray liquid volumes are recommended. With suitable treatment equipment (among others, sprayers with an auxiliary air stream [AAS]), the liquid dose can be reduced to 50-100 l/ha which should guarantee sufficient coverage of the treated plants.

Choice of nozzles

Spray nozzles have a direct impact on the quality of spraying and thus on the safety and effectiveness of plant protection products. Catalogues and general recommendations for their use in the protection of agricultural crops are useful in selecting the right nozzles for particular crop 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 should be prepared immediately before the procedure to avoid undesirable physicochemical reactions. The agitator of the sprayer must be switched on at all times to prevent the mixture from precipitating at the bottom of the tank. Before pouring the product into the tank, it is necessary to read the indications on the label as to the method of preparation of the spray liquid and the possibility of mixing the product with other preparations, adjuvants or fertilisers.

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, underground water, and soil and at a distance of no less than 20 m from wells, water intakes, reservoirs, and watercourses.

<u>Filling the sprayer</u>:

- the sprayer must be filled on an impermeable and hardened surface (among others, a concrete slab) in a place where it is possible to prevent the spread 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,
- plant protection product packaging must be rinsed three times, the contents poured into the spray tank, and the packaging preferably returned to the dealer,
- if possible, it is best to fill the sprayer on a special stand with a biologically active substrate,
- when filling the sprayer on a permeable medium, a thick foil for the collection of spilled or scattered preparations should be laid down where plant protection products are measured and introduced into the sprayer tank,
- spilled or scattered plant protection products and contaminated material must be safely managed using absorbent material (among other things, sawdust),
- contaminated absorbent material should be collected and deposited at the plant protection product bioremediation site, or placed in a sealed, labelled container,
- the container with the contaminated material should be stored in the plant protection product storage area until safe disposal.

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 (including urea, magnesium sulphate) is poured into the sprayer tank half filled with water with the stirrer on. Further components should be added to this solution. It is recommended that they be pre-diluted before pouring into the sprayer tank. Begin with an adjuvant to improve the compatibility of the mixture components, if any. Plant protection products are then added (in the correct order – according to the formulation) and topped up with water to the desired volume of the sprayer tank.

In large-component mixtures using two or more plant protection products, the order in which they are added to the liquid must be followed – according to the physical properties of the formulations. First add preparations that form a suspension in water, then add products that form emulsions and finally solutions. Once all the ingredients have been added, top up the container with water to the required volume.

Low-temperature water (taken directly from a deep well) should not be used for the treatment. Hard and polluted water should not be used. Once the spray has been properly formulated, protective treatments can be carried out.

Conditions for performing the procedure

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 inclement weather (stronger winds, high temperatures and low humidity) can cause damage to other plants due to spray liquid drift onto untreated areas, and can also cause unintentional poisoning of many beneficial entomofauna species.

Table 7 shows recommendations for optimal and limiting weather conditions during spray applications. The recommended air temperatures during treatments are conditioned by the type and mechanism of action of the plant protection product applied and such data are included in the label texts. For most preparations, their optimal effectiveness is achieved at a temperature of 12-20 °C.

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

Table 7. Limit and optimal meteorological conditions for plant protection treatments

Parameter	**Limits values (extreme)**	**Optimal values (most favourable)**
Temperature	1-25 °C during treatment	12-20 °C during treatment
	up to 25 °C the day after treatment	20 °C on the day after treatment
	not less than 1 °C the following night	not less than 1 °C the following
Air humidity	40-95%	75-95%
Precipitation	less than 0.1 mm during treatment	without precipitation
	less than 2.0 mm within 3-6 hours after treatment	

Wind speed	0.0-4.0 m/s	0.5-1.5 m/s

Plant protection products in the open field shall be applied using tractor and self-propelled field or orchard sprayers if the application site is remote:

- at least 20 m from 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;
- 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.

The obligation to comply with the provisions of the plant protection product labels in the first instance should be kept in mind. In many labels, distances (buffer zones) greater than those indicated above are given from specific sites and facilities after which plant protection products should be used.

The spraying procedure is carried out at a constant displacement speed and working pressure determined during sprayer adjustment. Carry out successive passes over the field very precisely in order to avoid the formation of unsprayed strips and to prevent the sprayed liquid from overlapping with already sprayed areas.

Post-treatment procedure

At the end of each treatment cycle, removal of the residual 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 its own unused agricultural area, away from drinking water intakes, and sewer wells. The sprayer should be washed thoroughly, in a place intended for this purpose.

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

Cleaning and rinsing of the tank and the liquid system of the sprayer must be carried out at a safe distance – no less than 30 m – from wells, water intakes and bodies of water n.

<u>Procedure for rinsing tank and liquid installation</u>

- 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 3 times,
- switch on the pump and, with the nozzle supply closed, flush all components of the liquid system used during treatment,

- spray the washings onto the area previously sprayed or, if this is not possible, use the remaining liquid in accordance with the recommendations for the management of liquid residues.
- dispose of any residual, drained liquid from the sprayer using technical devices that ensure biological biodegradation of the active substances of the plant protection product. Until neutralisation or disposal, liquid residues can be stored in a dedicated sealed, labelled and secured container.

External washing of sprayer

At the end of the working day, the outside of the entire apparatus, as well as components in contact with chemicals, should be washed with water:

- 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/remediation system (among others, Biobed, Phytobac, Vertibac site); if this is not possible, it is best to wash the sprayer in the field,
- wash the sprayer with a small amount of water, preferably using a high-pressure lance instead of a brush, to reduce the time and effectiveness of external cleaning,
- use recommended biodegradable cleaning agents to enhance cleaning efficiency.

Registration of treatments

Professional users of plant protection products are required to maintain and keep records of their plant protection products for at least three years. In the integrated production of maize, the role of the register is played by the integrated plant production notebook.

11. HYGIENE AND HEALTH PRINCIPLES

A. Personal hygiene of employees

1. Persons working in the harvesting and preparation of crop for sale should:
   a. maintain personal cleanliness, observe hygiene rules and in particular wash hands frequently at work;
   b. wear clean clothing and, where necessary, protective clothing;
   c. apply watertight dressings to skin cuts and scratches.

B. Requirements of hygiene relating to agricultural produce prepared for sale

The plant producer should take measures, as appropriate, to ensure that agricultural products are protected during and after harvest from physical, chemical and biological contamination.

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

Growers in an Integrated Crop Production system will take appropriate measures to ensure that:

a. rooms (equipment included), means of transport and packaging are kept clean;
b. no farm and domestic animals enter the premises, come in contact with vehicles and packaging;

c. harmful organisms (pests and organisms dangerous to humans), which may lead to contamination or pose a threat to human health, e.g. mycotoxins, are eliminated;
d. hazardous waste and substances are not stored together with crops prepared for sale.

12. CROP HARVESTING

Sweetcorn cobs for direct consumption are harvested when the kernels have reached the milk stage. For processing, sweetcorn must be harvested at the milk-wax stage but before the wax maturity stage. This stage can be approximately determined when the filiform stigmas of the pistils are completely dry. During this period, the grain contains 24 to 28 % dry matter.

In the milk-wax phase, sweetcorn kernels contain the highest amount of nutrients. The grain is shiny, yellow or white. The filiform stigmas of the pistils, which protrude outside the cob, are dark brown and partly shrivelled, while inside the cob they are still green. The leaves covering the cob are still green and juicy. The simplest way to determine the milk maturity of the grain is by pressing it with a fingernail. When the kernel is squeezed, a thick milky sap is released, indicating that the sweetcorn has reached the desired degree of ripeness. If water flows out of the grain, it is not ripe enough; if no liquid flows out, it is overripe and unfit for consumption.

Harvesting takes place approximately 21 days after the filiform stigmas of the pistils (also known as silks or tassels) appear outside the cob. It depends on the weather pattern and the cultivar. For direct consumption, cobs can be harvested from early to late maturity. The younger the cobs, the higher the sugar content, but the kernels are less likely to germinate, resulting in a lower yield. If harvested too late, the kernels begin to harden and the flavour of the sweetcorn deteriorates significantly. Here the sugar content drops rapidly, especially sucrose, which gives the grain its sweet taste. The kernels become increasingly mealy and the fruit and seed shells become increasingly hard. For most cultivated sweet corn cultivars, the optimum harvest date is usually 2 to 3 days in hot weather. Up to 10 days may be required for harvesting in cold weather.

Sweetcorn cobs are harvested mechanically with special combine harvesters or alternatively by hand. Combine harvesting is used on larger plantations, while manual harvesting is often used on smaller plantations (despite the greater workload).

Super sweet varieties lose sugar more slowly after harvest than normal sweet varieties. Care should be taken to ensure that maize is harvested during the cold part of the day, i.e. in the morning or evening. The distance to the recipient should be short. The idea is that the maize needs to be cooled quickly, i.e. it needs to be cold stored as soon as possible. Sweetcorn should be processed within 12-24 hours of harvest. Sweetcorn can only be stored in the cold store in its husk. Maize to be eaten later should be cooled to around 0 °C. However, at this temperature it can be stored for no more than 4 to 5 days. It should be noted that not all cobs on a plant ripen at the same time. The most vigorous cobs on the main stem mature earlier. On the other hand, the cobs growing below or above the main cob and on the side shoots ripen a little later. In order to obtain cobs that are reasonably even in maturity, they should be harvested two or even three times at short intervals, but only if harvested by hand. During a single mechanical harvest, some cobs may be slightly overripe, while others may be underripe.

In order to limit the development of pests (mainly European corn borer) and evaporation, the necessary post-harvest treatment is to shred or mix the harvested residues with the top layer of soil within 30 days at the latest.

13. MAIZE DEVELOPMENT STAGES BASED ON THE BBCH SCALE

Scales describing the development of crop plants are of use to plant producers and advisers in accurately determining the developmental stage of a plant, among others, during cultivation work and the application of plant protection products. One of the more commonly used scales that succinctly yet clearly describes the phenological development of crop plants is the BBCH scale.

The standard description of the main developmental stages according to the BBCH scale, in the form of a two-digit code indicating the different stages of plant development, is the same for different plant species, regardless of language or country. The first digit identifies the main development stage and the second digit is a detail of the advancement in development of the main stage. During the development of maize, 6 major development stages can be distinguished. These are:

- germination and emergence,
- leaf development,
- lengthening of the stem,
- inflorescence development,
- flowering,
- development of kernels and their maturation.

Maize – *Zea mays* L.

CODE DESCRIPTION

Principal growth stage 0: Germination
00 Dry kernel (caryopsis)
01 Beginning of kernel swelling
03 End of kernels swelling
05 Radicle emerges from kernel
06 Radicle elongated, root hairs and/or side roots visible
07 Leaf sheath (coleoptile) emerges from kernels
09 Emergence: coleoptile penetrates soil surface(cracking stage)

Principal growth stage 1: Leaf development[1, 2]
10 First leaf is formed from the coleoptile
11 1 leaf unfolded
12 2 leaf unfolded
13 3 leaves unfolded
1. Stages continuous till...
19 9 or more leaves have unfolded

Principal growth stage 3: Stem elongation (shoot elongation)

30 Beginning of stem elongation
31 1 nodes detectable
32 2 nodes detectable
33 3 nodes detectable
3. Stages continuous till...
39 9 or more nodes detectable[3]

Principal growth stage 5: Inflorescence emergence, heading
51 Beginning of tassel emergence: tassel detectable at top of stem
53 Tip of tassel visible
55 Middle of tassel emergence: middle of tassel begins to separate
59 End of tassel emergence: tassel fully emerged and separated

Principal growth stage 6: Flowering, anthesis
61 (M) Stamens visible in the spikelets of the central part
(F) Cob emerges from the leaf sheath
63 (M) Beginning of pollen shedding
(F) Visible stigmas of the pistils
65 (M) Flowering of the upper and lower part of the tassel
(F) Pistil stigmas fully developed
67 (M) Full flowering
(F) Stigmas and styles of pistils dying off (browning)
69 End of flowering: stigmata and pistil collars completely dry (dead)

Principal growth stage 7: Development of fruit
71 Development of the first kernels with a watery consistency, containing about 16% dry matter.
73 Beginning of milk stage of kernels
75 Kernels are fully mature and contain approximately 40% dry matter.
79 Nearly all kernels have reached final size

Principal growth stage 8: Ripening
83 Early waxy ripeness of kernels: soft kernels contain about 45% dry matter.
85 Full waxy ripeness of kernels: kernels with typical colour contain about 55% dry matter.
87 Physiological ripeness: visible black spots at the base of the kernels contain approximately 60% dry matter.
89 Fully ripe: kernels hard and shiny, about 65% dry matter

Principal growth stage 9: Senescence
97 Plant wilts and dies
99 Harvested product

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[1] A leaf may be described as unfolded when its ligule is visible or the tip of the next leaf is visible
[2] Shoot elongation may take place earlier than stage 19 in which case it continues into the principal growth stage 3

[3] Tassel emergence may occur earlier, in this case continue with principal growth stage 5

Maize

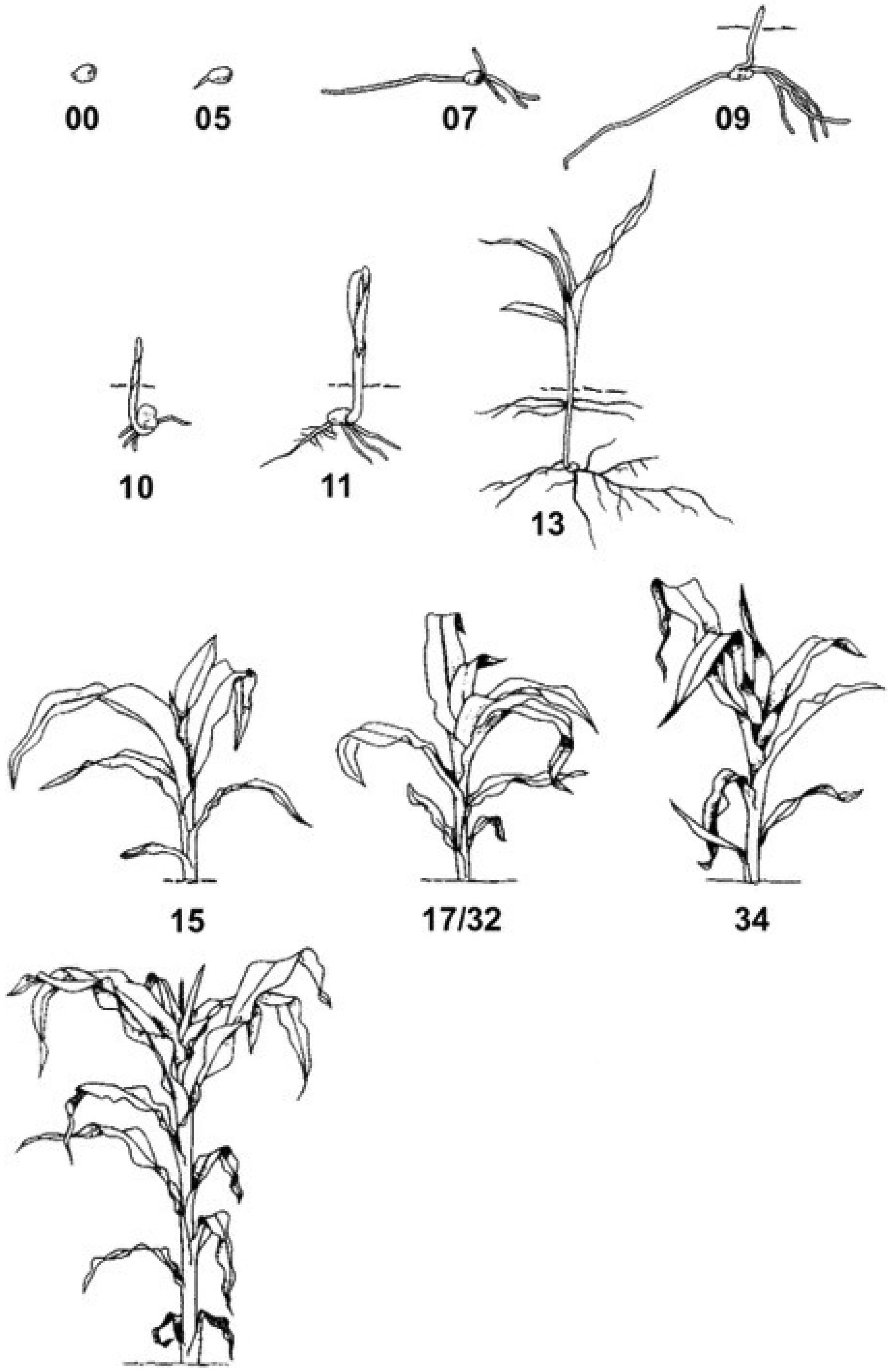

Figure 1. Development stages of maize (*Zea mays* L.) on the BBCH scale

14. RULES FOR KEEPING DOCUMENTATION IN INTEGRATED PRODUCTION

Inherent in the cultivation of plants in the Integrated Plant Production (IP) system is the maintenance or possession of various documentation by the agricultural producer. The IP Notebook is one of the most important of these documents. The template is set out in the Annex to the Regulation of the Minister of Agriculture and Rural Development of 24 June 2013 on documentation of activities related to integrated plant production.

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

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

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

The application form should be completed with information such as:

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

The application must also include the date and signature of the applicant. The declaration shall be accompanied by information on the species and varieties of plants to be grown under the IP system and the location and area of their cultivation. A copy of the certificate of completion of training in integrated plant production or a copy of the certificate or copies of other documents proving the qualification must also be attached to the application.

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

The notebook should be filled in according to the following scheme.

Cover – on the cover we write the species of crop grown, the year of production and the number in the register of plant producers. We then complete our own information.

Inventory of fields (…) in the integrated plant production syste m – list all cultivated varieties declared for IP certification in the field inventory table.

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

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

Purchased plant protection products – in the table we record the purchased plant protection products (trade name and quantity) intended to protect the crop for which the notebook is kept.

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

Crop rotation – complete the crop rotation table by entering the crop with the code of the field on which it was applied. Crop rotations must be reported for the period (number of years) specified in the methodology.

Seed (…) – complete the table with information on the material purchased – variety, level of certification, quantity and proof of purchase (invoice, plant passport or official label).

Sowing (…) – record the amount of seed used in each field in the table. Also note the dates of the activities performed. For this purpose, tick the relevant boxes (□) to confirm the information on soil testing/assessment for existing pests which would exclude the field from IP cultivation.

Soil/substrate and plant analysis and fertilisation/fertigation - soil analysis is a fundamental activity to determine the fertiliser needs of plants. The IP producer must carry out such analyses and record them in the notebook. In the table "Soil and plant analysis" we enter the field code, the type or scope of the tests and the number and date of the report. In the "Organic fertilisation (…)" table, note all organic fertilisers applied. If green fertiliser is used, the type or composition of the mixture is indicated in the "Type of fertiliser" column. In the next table, "Soil mineral fertilisation and liming", note the date and type and dose of fertilisation and liming applied and where it was applied. The table “Observations of physiological disturbances and foliar fertilisation” is a record of observations for plant nutritional deficiencies and constitutes a register of fertilisers used. The IP producer must regularly inspect the crops for the presence of physiological diseases and record this fact each time. Foliar fertilisation should be correlated with the conducted observations of physiological disorders.

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

Harvest – in this table, record the quantities of crop taken from each field.

Hygiene and sanitation requirements – record whether people in direct contact with food have access to clean toilets and hand-washing facilities, cleaning products, and paper towels or hand dryers. It should also be described how hygiene and sanitary requirements are observed in relation to IP methodologies.

Other mandatory requirements for the protection of plants against pests according to the requirements of the method – a notebook page with space for the IP producer to comment on the requirements for the protection of plants against pests set out in the integrated crop production method.

Information relating to the cleaning of machinery, equipment and facilities used in production, as required by the Integrated Production Methodology – a notepad page with space for the IP manufacturer to record information relating to the cleaning of machinery, equipment and facilities used in production, as required by the Integrated Production Methodology.

The notebook also contains a space for comments and own notes and a list of attachments.

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

15. LIST OF MANDATORY ACTIVITIES AND TREATMENTS IN INTEGRATED PRODUCTION (IP) OF SWEETCORN

Mandatory requirements (100% compliance, i.e. 13 points)			
Item	**Checkpoints**	**YES/NO**	**Comment**
1.	Use of appropriate crop rotation – using precursor crops indicated in the methodology (**ch. 3.3**)	❑/❑	
2.	Selection of cultivars adapted to the soil-climatic conditions in a given area of cultivation (**ch. 4**).	❑/❑	
3.	Use of certified seed and sowing at the appropriate time for the region, with the appropriate standard and parameters of sowing while maintaining the spatial isolation from other maize crops indicated in the methodology (**ch. 5.2**).	❑/❑	
4.	Use at appropriate dates and fertilisation rates depending on the type and pH of the soil after prior completion of the nutrient balance supported by documents (**ch. 6**).	❑/❑	
5.	Post-emergence weed control involves first of all agronotechnological methods such as hoeing and, in the case of chemical protection, the correct post-emergence application of a herbicide at the appropriate rate (**ch. 7.1**).	❑/❑	
6.	Systematic monitoring (at least 1x per week) from emergence to maturity of disease incidence (ch. **7.2.2**).	❑/❑	
7.	Systematic monitoring (at least 1x per week) from emergence to the beginning of maturity of the occurrence of pests using the indicated methods (ch. **7.3.2**).	❑/❑	
8.	Rotational use of active substances of plant protection products from different chemical groups to prevent resistance in pests (weeds, pests and pathogens) taking into account the extent of protection in previous seasons (**ch. 7**).	❑/❑	
9.	Carrying out at least one treatment using biological plant protection products to control pests or maize diseases (**ch. 8**).	❑/❑	
10.	Using only plant protection products on the list of products authorised for use in integrated sweetcorn production (**ch. 7, ch. 8**).	❑/❑	
11.	Creating suitable conditions for the presence of birds of prey, e.g. perching poles (**ch. 9**).	❑/❑	
12.	Placement of "houses" for mason bees or mounds for bumblebees or other structures for pollinating insects(**ch. 9.**)		
13.	Timely harvesting of the crop at harvest maturity and application of post-harvest tillage as indicated in the methodology (**ch. 12**).	❑/❑	

Note:
Satisfying all the requirements in the list of mandatory operations and treatments under the integrated plant production system must be documented in the integrated plant production Notebook.

16. IP CHECKLIST FOR VEGETABLE CROPS

Basic requirements (100 % compliance, i.e. 28 points)			
No.	Checkpoints	YES/NO	Comment
1.	Does the producer produce and protect the crops according to detailed methodologies approved by the	/	

	Main Inspector?		
2.	Does the producer have up-to-date IP training confirmed by a certificate, subject to Articles 64(4), (5), (7) and (8) of the Crop Protection Products Act?	/	
3.	Are all required documents (e.g. methodologies, notebooks) present and kept on the farm?	/	
4.	Is the IP Notebook kept correctly and up to date?	/	
5.	Does the producer apply fertilisation on the basis of the actual nutrient requirements of the crops, determined in particular on the basis of soil or crop analyses?	/	
6.	Does the producer systematically monitor the crops and record them in a notebook?	/	
7.	Does the producer deal with empty packaging of crop protection products and products that are out of date in accordance with the applicable legal regulations?	/	
8.	Is chemical protection of crops replaced by alternative methods wherever justified?	/	
9.	Where possible, is chemical plant protection conducted based on commercial threat thresholds and pest forecasting and monitoring?	/	
10.	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?	/	
11.	Are the applied plant protection products approved for use in the plant?	/	
12.	Is each use of plant protection products recorded in the IP Notebook, taking into account the reason for use, the date and place of use and the surface area of cultivation, the dose of the preparation and the amount of spray liquid per unit of surface area?	/	
13.	Were the plant protection treatments carried out under appropriate conditions (optimal temperature, wind below 4 m/s)?	/	
14.	Is the rotation of the active substances of the crop protection products used for the treatments respected, if possible?	/	
15.	Does the producer limit the number of treatments and the amount of crop protection products used to a necessary minimum?	/	
16.	Does the producer have measuring devices to precisely determine the quantity of the measured plant protection agent?	/	
17.	Are the conditions for safe use of the agents respected, as set out on the labels?	/	
18.	Does the producer comply with the provisions of the label concerning the observance of precautions related to environmental protection, i.e. e.g. the observance of protective zones and safe distance from areas not used for agricultural purposes?	/	
19.	Are prevention and grace periods observed?	/	

20.	Are the doses and maximum number of treatments per growing season specified on the label of the plant protection product not exceeded?	/	
21.	Are the sprayers referred to in the IP Notebook in good technical condition and are their technical inspection certificates up to date?	/	
22.	Does the producer carry out systematic calibration of the sprayer(s)?	/	
23.	Does the producer have a separate place for the filling and washing of sprayers?		
24.	Does the handling of usable residual liquid comply with the provisions indicated on the labels of plant protection products?	/	
25.	Are crop protection products stored in a marked closed room in such a way as to prevent contamination of the environment?	/	
26.	Are all crop protection products stored exclusively in their original packaging?	/	
27.	Does the IP producer observe hygienic and sanitary principles, especially those specified in the methodologies?	/	
28.	Are appropriate conditions for the development and protection of beneficial organisms ensured?	/	
	Total points		

Additional requirements for field vegetable crops (minimum compliance 50 %, i.e. 10 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Were the plant varieties grown selected for Integrated Plant Production?	/	
2.	Is each box marked according to the entry in the IP Notebook?	/	
3.	Did the producer perform all the necessary agrotechnological procedures in accordance with IP methodologies?	/	
4.	Is the recommended catch crop used in cultivation?	/	
5.	Are steps taken on the holding to reduce soil erosion?	/	
6.	Are expired plant protection products stored separately in the plant protection products warehouse?	/	
7.	Have the procedures been conducted using spraying devices specified in the IP notebook?	/	

8.	Are protective clothing and health and safety rules observed during care work, especially during spraying?	/	
9.	Are fertiliser application machines maintained in good working order?	/	
10.	Do fertiliser application machines allow for accurate dose determination?	/	
11.	Is each fertiliser applied recorded with regard to its form, type, date of application, quantity, location and surface?	/	
12.	Are fertilisers stored in a separate and specially designated room in a manner that ensures protection of the environment against contamination?	/	
13.	Does the producer protect empty PPP packaging against unauthorised access?	/	
14.	Is water of drinking water class used for washing vegetables?	/	
15.	Is the access of animals to storage, packaging and other processing areas for crops restricted?	/	
16.	Does the producer have a properly prepared place to collect organic residues and sorted vegetables?	/	
17.	Are there first-aid kits near the workplace?	/	
18.	Are dangerous locations clearly marked on the farm, e.g. storage areas for crop protection products?	/	
19.	Does the producer use consultancy services?	/	
	Total points		

Recommendations (implementation min. 20 %, i.e. 3 points)			
No.	**Checkpoints**	**YES/NO**	**Comment**
1.	Are soil maps drawn up for the farm?	/	
2.	Are inorganic fertilisers stored in a clean and dry room?	/	
3.	Is a chemical analysis of organic fertilisers on the content of nutrients performed?	/	
4.	Is there an irrigation system on the farm that ensures optimal water consumption?	/	
5.	Is the irrigation water tested in a laboratory for microbiological and chemical contamination?	/	
6.	Does the lighting in the room where the plant protection products are stored make it possible to read the information on the packaging of the plant protection products?	/	
7.	Does the producer know how to proceed in the event of spill or scatter of plant protection products and do they have tools to counteract such a threat?	/	
8.	Does the producer restrict access to the keys and the warehouse in which the plant protection products are stored, to persons who do not have the authority to use them?	/	
9.	Does the producer store on the farm only plant protection products allowed for use with the plant species they cultivate?	/	
10.	Is the water used to prepare the spray liquid of the correct quality, including the correct pH?	/	
11.	Are wetting agents or adjuvants added to the spray liquid to improve the effectiveness of treatments?	/	
12.	Does the producer improve their knowledge at Integrated Plant Production meetings, courses or conferences?	/	
	Total points		

17. SUPPLEMENTARY LITERATURE

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