MAIN INSPECTORATE FOR PLANT HEALTH AND SEED INSPECTION

DRAFT

METHODOLOGY FOR THE INTEGRATED PRODUCTION OF HAZELNUT

(first edition)

Approved

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

(consolidated text: Journal of Laws [Dziennik Ustaw] 2024, item 630)

by

the Main Inspector of Plant Health and Seed Inspection

Warsaw, February 2025

INTEGROWANA PRODUKCJA

URZĘDOWO KONTROLOWANA

Approved by
~~/signed electronically/~~

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ISBN 978-83-67039-49-9

Photograph on the cover: Grzegorz Hodun

The methodology was developed as part of the special grant of the Ministry of Agriculture
and Rural Development, Task 6.3. ‘Updating and developing methodologies for integrated plant protection, Integrated Plant Production, and signalling guides’.

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PREFACE

Integrated plant production (IP) is a modern cultivation system that combines the principles of sustainable agriculture and care for the natural environment. It aims to minimise the impact of chemical plant protection products on the ecosystem while ensuring high quality yields and efficient production. In practice, integrated production means the harmonious application of biological, mechanical and chemical methods in the protection and care of plants, which allows for sustainable crop development. This system is gaining increasing popularity among producers, but its scale is not as developed as in other European countries yet. One of the main elements of the system is the application of the principles of integrated plant protection, which have been mandatory for all professional users of plant protection products since 1 January 2014. Its assumptions are based on the use of various methods of reducing pest pressure as well as on minimising impact on the environment and human health by reducing the use of chemical plant protection products. They are used only when necessary, i.e. when risk thresholds are exceeded and when biological or mechanical measures cannot be applied effectively. In addition to applying integrated protection, integrated production supports actions aimed at preserving biodiversity in the crop ecosystem by using refuges in the form of, e.g., field trees, facilitating the protection of predators and parasitoids of pests, which contributes to increasing the resilience and stability of the environment. An important part of integrated plant production is the sustainable management of soil by using crop rotation wherever possible and erosion mitigation measures to maintain soil fertility. In addition, integrated plant production also includes elements such as rational fertilisation, which means the application of fertilisers adapted to the actual needs of the plants, and entails the need for regular monitoring of the condition of soil and plants. An important element of integrated plant production is proper variety selection, which takes into account not only consumer preferences, but also pest resistance and adaptation to local climate and soil conditions. In the era of climate change, which we have been dealing with in recent years, it is also necessary to emphasise the need for efficient management of water resources.

Participation in the scheme is voluntary. Manufacturers who decide to implement it obtain a certificate that confirms that they conduct production in accordance with IP rules. The certification system for integrated production (IP) in agriculture in Poland is regulated in detail by law and includes a number of conditions that must be met by agricultural producers. Its certification is conducted by certification bodies authorised and inspected by regional inspectorates of plant health and seed inspection. The legal provisions on Integrated Plant Production are regulated by the Plant Protection Products Act of 8 March 2013 (consolidated text: Journal of Laws 2024, item 630), Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on documenting activities related to integrated plant production (Journal of Laws 2023, item 2501) and Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on the qualifications of persons carrying out inspections of compliance with the requirements of integrated plant

production and the model certificate certifying the use of integrated plant production(consolidated text: Journal of Laws 2023, item 1397) and Regulation of the Minister for Agriculture and Rural Development of 8 May 2013 on plant protection product training (Journal of Laws 2022, item 824).

Above all, the IP certificate may be granted if, among other things, production is carried out in accordance with methodologies approved by the Main Inspector for Plant Health and Seed Inspection.

The methodology of integrated hazelnut production covers issues related to cultivation, protection and fertilisation, from soil preparation and planting, through agrotechnical treatments and protection against pests, to harvesting and storing hazelnuts. It also discusses the hygiene and sanitary rules that need to be complied with during the harvest and preparation of crops produced in the IP system for sale, and the general rules governing the issue of IP certificates.

This methodology was developed based on the results of proprietary research and the latest data from the literature, in compliance with integrated plant protection requirements and the guidelines of the International Organisation for Biological and Integrated Control (IOBC), and the International Society for Horticultural Science.

I. ESTABLISHMENT OF PLANTATIONS

Grzegorz Hodun, Msc

1. Site selection

The cultivars of hazel come from two wild-growing species: Pontine hazel (Corylus avellana var. pontica Winkl.) and Long-eared hazel (C.tubulosa Willd.). Some of them are also crossbreeds of both species or their crossbreeds with common hazel (C.avellana L.). Pontine hazel and Long-eared hazel occur in south-west Asia and south-eastern Europe, while common hazel is also found in Poland – on the banks of rivers and lakes, in forests and field trees.

Due to this origin, the hazel has quite high thermal requirements. It also needs good sunshine, which in Poland determines both the place of its cultivation and the form of its conduct. In our conditions, it is recommended that shoots be grown in the form of trees in order to ensure that the hazel gives sufficient illumination to the shoots. A suitable place for planting hazel trees are small hills with a south-eastern, south-western or western exhibition, or flat areas slightly elevated, from which the outflow of cold air masses in the pre-spring is possible. When growing hazel, it is necessary to avoid hills with a southern exhibition, which generally creates better thermal conditions, but promotes the rapid heating of such places during winter and spring warming, which leads to premature flowering of plants, and then freezing of at least some of the inflorescences after the return of negative temperatures. It is also necessary to avoid the so-called frost stagnations, which form both in field depressions and in places sheltered, for example, by a high, compact hedge. In sites exposed to strong winds, it is advisable to create a natural open screen, e.g.

from the birches. Such a screen will significantly reduce the wind force, without completely reducing the flow of air necessary, among other things, to transmit the pollen of the hazel during flowering time.

The hazel can grow on different soils, although it yields best on soils that are permeable, rich in humus and nutrients, with a pH close to neutral (pH 6.5-7.2) or slightly alkaline. It is not recommended for cultivation in heavy and waterlogged soils, nor in light and excessively permeable soils. Heavy clays, sandy soils, as well as gravel soils should therefore be avoided. The proper conditions for growth and fruiting of hazel are provided by rendzinas, black earths, proper brown soils, as well as soils developed from loess formations, light and medium clay or carbonate rocks. Sandy and loamy soils will also be suitable for growing hazel.

2. Soil preparation and forecrops

As hazel is a perennial plant, the errors made at the planning stage and in the establishment of its plantations often last for many years. To avoid this, a chemical analysis of the soil should be conducted prior to planting to determine the reaction and nutrient content of the soil, among other things.

The majority of the soils used for agriculture are slightly acidic or acidic in Poland. Since hazel requires soil with a pH close to neutral, liming is often necessary before establishing its plantation. It is good to do this one year before planting the trees, preferably in the autumn. For light soils, calcium carbonate forms are recommended, while for concise soils - oxide forms of this component. Calcium moves slowly in the soil, therefore, regardless of the form used, it is justified to mix it with the soil. For this purpose, after liming, it is necessary to first disk the soil and then perform medium-deep ploughing or ploughing with a subsoiler (a plough with a subsoiler will loosen the deeper layers of soil, allowing better penetration of air and rainwater).

In the spring of the following year, it is advisable to sow seeds of such plant species in such prepared soil that will improve their structure and at the same time enrich them with organic substances. These may be seeds of bean plants, e.g. lupin, or seeds of a mixture of these plants with cereals, e.g. oats flakes. Mustard or buckwheat, which, due to the short growing season, can be sown twice during the season, will also be a good pre-harvest for green fertiliser. During the period of maximum growth of green mass (usually at the end of flowering), the plants for green fertiliser should be mowed and crushed, and then shallowly ploughed or ploughed medium depth after prior plating. Root crops grown after applying high doses of manure (about 40 t/ha) can also be a valuable source of large amounts of organic mass.

If the time to prepare the field for hazel plantation is short, liming (if necessary) is carried out during the tree planting year, in late summer or early autumn, immediately after the harvest of the previously cultivated plants. Fermented manure, compost or compost substrate is then used as a source of organic mass. Manure is used in rows of trees, while compost or substrate is used to treat holes under trees. Neither compost nor substrate is

introduced into the hollow in a pure form – each one is mixed with the soil derived from the hollow in an appropriate proportion: 10-20 % by volume of compost or substrate and 80-90 % of soil. Only such a mixture is poured over the roots of planted plants.

Prior to plantation, the hazel soil must be enriched with phosphorus, if a shortage of this component has been identified. Phosphorus, like calcium, moves slowly in the soil, so it is worth mixing it into the soil before planting trees, when this is easy to do. Before establishing a plantation, it is also necessary to level the surface of the field intended for it. Any inequalities in the future will significantly hinder the harvesting of fruits, in particular the machine one.

3. Flowering and selection of varieties

Hazel is a monoecious dioecious plant, which means that on one tree or shrub it forms two types of flowers: male (staminate) and female (pistillate). Male flowers are gathered in long willows called catkins, initially they are green or reddish, and during pollination - yellow or pinkish. The female flowers are found in flower buds, outside which only reddish, elongated characters of the pistils form an inconspicuous shoot. Pollen from male flowers is transferred to female flowers by the wind, with fruit buds beginning to develop only in May, and not immediately after pollination.

Almost all cultivated varieties of hazel are self-incompatible, i.e. they do not set fruit after pollination with their own pollen. Pollen of other varieties is necessary for their formation, but even pollination with foreign pollen does not always lead to fertilisation of the egg and the formation of a fruit, since some varieties are incompatible with each other. Detailed information on the selection of pollinators for varieties grown in Poland is lacking in the available literature. Therefore, as if conservatively, on the hazel plantations we plant not one, but usually two pollinating varieties. Trees of the basic variety are arranged alternately with pollinator trees, most often in a system: two or three rows of pollinated variety and two rows of pollinator varieties. This arrangement of varieties ensures that the distance between the pollinated and pollinating variety is no greater than 20 m, which should ensure good yields, provided that the male inflorescences do not freeze.

The hazel blooms very early, in February or March, after a few days of warming. The increase in temperature during this period causes the male inflorescences to gradually relax, the inflorescences to lengthen and the pollen to mature, while the stigmata of the pistils generally still remain hidden in the flower buds.

If the warming period is long enough, the stigmata protrude and full pollination occurs. If it is too short, pollination is poor because only some of the female flowers develop (the stigmata of the pistils appear), and the rachis of the male inflorescences freeze to a large extent (the pollen on them dies). As a result, fruiting is later negligible or non-existent. Even in such a situation, the crop can be saved because the female inflorescences retain the ability to elongate their stigmata and receive pollen for a long time. All that needs to be done is to perform artificial pollination during the next warming period.

In order to obtain pollen for artificial pollination, during the first warming period, an

appropriate number of branches with male inflorescences are cut. The felled shoots are inserted into the dish with water in a dry, sunny place. A suitably large foil is placed under the vessel, from which the fallen pollen is later collected. The second foil covers the branches in order to avoid excessive drying of the cut shoots. After a few days, when the catkins have lengthened, the foil is removed from the shoots and the pollen that has fallen off is collected in a foil bag or jar. Tightly closed it is stored in a refrigerator. A few days after the reddish stigmata appear, flowering trees are sprayed with a suspension of such pollen in water. Due to the uneven development of female flowers, such spraying is worth repeating after 7-10 days. In this way, despite damage to male flowers on the trees, a good yield can be obtained.

In Poland, relatively few varieties of hazel are available for cultivation. However, these are varieties tested in our climatic conditions, in most cases entered in the COBOR Varieties Register (https://www.coboru.gov.pl/pdo/ipr), which should not surprise hazelnut producers in the right growing conditions. Growing other varieties that have not been tested with us is possible, but with a greater or lesser risk.

The choice of variety for commodity cultivation is determined by a number of factors, of which the ease of harvesting and marketing the fruit is particularly important.

The possibility of selling nuts is particularly important from the point of view of the profitability of production. Before placing a plantation, it is therefore useful to know the preferences of both their direct consumers and processors. It is also worth knowing that most varieties grown in Poland produce dessert and processing nuts.

4. Nursery material and planting

We order nursery material in accordance with the adopted plan, which includes both the quantitative needs of the different varieties and the qualitative needs, depending on the cultivation technology adopted. In our conditions, it is recommended to grow hazel in the form of trunk trees, and the height of the trunk depends on the method of harvesting, e.g. the use of shakers or other devices for harvesting nuts. The use of different equipment should be taken into account when planning the spacing of the rows, which should enable the equipment to be easily used during harvesting. Usually, a distance of 4 m is maintained between rows of hazel trees, but with some equipment it would be better to increase the distance to, e.g., 5 m.

Trees that have been ground or air layered are used for starting a hazel plantation. Air layered trees are recommended more often because they have a more developed root system and a straight leader, often with several lateral shoots (photograph 1).

The hazel plantation is worth setting up with high-quality nursery material. This will ensure a good start for planted plants and, later, facilitate and accelerate their shaping. Good quality nursery material is considered to be trees with a well-developed root system, with a height of approximately 120 cm and a diameter of the stem at a height of 15 cm from the ground of not less than 1.2 cm. Although trees with a height of approximately 80 cm (CAC category) are allowed to be marketed, it is advisable to purchase trees which are better

grown, especially when nuts are to be harvested mechanically. With mechanical shaking of nuts, deriving a tall, nearly 80-centimeter trunk from about 80-centimeter trees will require an additional year of cultivation. From nursery stock of this height, trees grown for manual harvesting can be quickly formed, for which 50-60 cm stem height will be sufficient. The trees for establishing a hazelnut plantation, regardless of the type of harvest, should have resilient roots and firm shoots with non-broken buds. In practice, this means that trees need to be properly transported from the nursery to their final destination. Trees should be transported in a closed luggage box, with roots covered with foil or a special mat.

Photograph 1. Hazel from vertical deposits

Trees transported in this way should be earthed until they are planted. For this purpose, a deep pit is excavated, in which individual stems of trees are placed, and their roots are then buried into the ground.

Hazelnut trees may be planted either in the autumn or in spring. The autumn term is more likely to be recommended, as the buds needed to form the crown are much easier to break down in spring. In addition, trees planted in the spring period must be stored until planting in a cold store. Regardless of when the plantation will be established, it is better to plant trees during cloudy, not too windy weather, so that there is no excessive drying of the roots, and as a result, the deterioration of the condition of the plants.

Hazelnut trees, like other species, are planted according to a previously prepared plan, keeping the fixed spacing and arrangement of the varieties. Rows and planting sites may be plotted a day or two before planting, while pits under the tree should be dug on the day of planting – shortly before it if the pits are dug with a drill, or immediately before planting if they are dug by hand. The hazel trees are planted in wells approximately 25 cm deep and approximately 30 cm in diameter. Immediately before placing the tree in a pit, the roots are reduced to such a length that the tree fits freely into the well. The planted tree is placed in a

hole on a small mound scattered from humus soil. This soil is also filled with the wells, at the end with a slight fixation of it. Trees planted in this way should be watered as soon as possible, at the latest a day or two after planting.

5. Cultivation environment

A hazel plantation can be a valuable ecosystem from the point of view of nature conservation, the more valuable it is, the more diverse it is. With this in mind, it is also useful to design the immediate surroundings of the environment accordingly.

In the vicinity of hazel plantings there should be living shelters in the form of individual rows of trees of specific species. Trees in such covers should create openwork screens that only weaken the force of the wind. The flow of air within a hazelnut plantation is necessary both for the good yield and for the maintenance of the trees in good condition. The wind, which moves pollen from male inflorescences to female inflorescences, contributes to the process of fruit formation and, by drying wet leaves and shoots after rain, reduces the risk of fungal diseases. Only too strong wind is unfavourable, especially undesirable in the period of hazel blossoming (it takes pollen outside the plantation, and also increases damage to inflorescences during the return of low temperatures).

From the southern side of the hazel plantation, medium-growth trees should be planted so that they do not shade the trees of the basic species in the future. In such a location, amongst others, an edible dogwood will work perfectly, as its small, elliptical leaves allow for relatively free air circulation. In addition, from the dogwood — thanks to the dichotomy of the shoots — it is possible to form flattened trees that require little crown space and which, due to the numerous branches with succulent fruits, will be willingly populated by birds and insects. On any other side of the plantation, you can plant strongly growing trees, rather with a loose crown and small leaves, e.g. birch. Trees, but also small clusters of bushes planted in close surroundings of a hazelnut plantation accompanied by numerous animal species, primarily insects and small birds, will significantly increase the biodiversity of the sites where the hazelnut will be grown. The planting of the hazel and its surroundings should be scheduled at the same time.

II. FERTILISATION AND LIMING

Prof. Paweł Wójcik

Fertilisation of fruit plants is usually based on the results of soil and leaf analysis and visual assessment of the plant. Soil analysis is obligatory in integrated fruit production. Although chemical leaf analysis is a valuable complement to soil analysis, so far no so-called “cut-off numbers” have been developed for hazel. For this reason, hazel fertilisation strategy is based only on soil analysis and visual assessment.

An important factor in the development of a comprehensive plant fertilisation strategy is the way soil sampling is performed. Improper sampling increases the risk of errors in plant fertilisation, leading not only to lowering the yield of shrubs and the quality of the fruit, but also to increasing the susceptibility of plants to pests and pathogens and excessive pollution of the environment, mainly soil and water.

1. Soil analysis and its meaning in fertilisation strategy

1.1. Soil sampling and chemical analysis

Samples of soil should be taken separately from sites with different terrain layouts (upper, middle, and lower parts of a hill) and different fertilisation histories. If the plants are to be planted in a place where an orchard/plantation was previously cleared, soil samples are taken separately from the former herbicide strips and from under the turf.

On an existing plantation, soil samples should only be taken from the herbicide/mechanical fallow strips along the shrub rows. Samples should be taken within these strips, halfway between the plant row line and the edge of the turf. When the shrubs are irrigated with a drop system, samples should be taken about 20 cm from the emitter.

Before planting, soil samples are taken from two soil levels (0-20 cm and 21-40 cm), and in the case of an existing plantation, only from the surface layer of the soil (0-20 cm).

Prior to plantation establishment, soil samples should be taken a year before planting trees. On plantations, they are taken throughout the growing season once every 3 years on light soils and once every 4 years on heavier soils).

Soil samples are best taken with an Egner stick or auger. If these are not available, a spade can be used. When taking soil samples with a spade, cut soil patches of comparable depth and width. This is important because a mixed sample (coming from a homogeneous unit) should consist of 20-25 individual samples. After thoroughly mixing individual samples in a bucket, approximately 1 kg of soil (a so-called representative sample) should be taken, dried in a shaded place, placed in a canvas bag or cardboard box, signed and sent to the District Chemical-Agriculture Station or other agrochemical laboratory.

Basic soil analysis includes determining its reaction (pH) and the content of available phosphorus (P), potassium (K) and magnesium (Mg). It is also justified to assess the organic matter content and the granulometric composition of the soil.

1.2. Fertilisation with P, K and Mg

Fertilisation with the above ingredients consists in comparing the results of soil analysis with the so-called ‘limit numbers’ of P, K and Mg content (Tables 1-3). Depending on the component’s soil wealth class (low, optimal or high), a decision is made on the desirability of fertilisation with a particular nutrient and its dose.

1.3. Fertilisation with nitrogen (N)

The fertilisation needs of hazel plantations in relation to N are small and are determined on the basis of the organic matter content in the soil (Table 5). The given N

doses should be considered as indicative and should be verified with plant growth strength.

1.4. Liming

In temperate climates, there is a need to systematically raise the soil pH. For this purpose, deacidifying agents containing calcium (Ca) or Ca and Mg are used. Assessment of the need for liming and the amount of lime application depends on the soil pH, its agronomic category, and the period of lime used (Tables 6-8).

2. Visual method for assessing the condition of the plant

This method takes into account the growth strength of the plants, the appearance of the leaves, the intensity of flowering and the quality of the nuts. Table 1 presents the most important symptoms of deficiency of individual nutrients in the plant.

3. Fertilisation and liming before establishing the plantation

Organic fertilisation

The use of natural fertilisers obtained from animal production (e.g. manure, bird droppings), organic fertilisers from plant production (e.g. green manures, compost) or organic soil improvers before planting trees improves the yield of plants in the first years of their growth. This effect is particularly observed in light, low-humus soil. The positive effect of natural and organic fertilisers on the growth and yield of trees is the result of both providing plants with mineral nutrients and improving the physicochemical and biological properties of the soil.

Manure is a very valuable natural fertiliser. The maximum annual dose of manure must not exceed 170 kg N per ha (which generally corresponds to 35-40 tonnes of manure). The date of application of manure depends on the plantation period and the agronomic soil category. On light soil, manure should be used in spring. If trees are planted in autumn on light soil, manure should be applied under the preceding crop.

Green fertilisers intended for ploughing are an alternative to manure. The fertilising value of these plants depends on the amount of biomass produced and its mineral content. Fabaceae plants (legumes and small-seed plants) have a high fertilising value. In addition to them, plants with fast biomass production are also recommended. However, high biomass production depends on the proper selection of plant species for soil fertility. In light soil, you should grow: yellow and narrow-leafed lupine, phacelia, oats, serradella, sunflower, mustard or buckwheat; in medium soil - field pea, sainfoin, spring vetch or common birdsfoot, and in heavy soil - blue lupine or field bean.

In order to reduce the costs of growing crops for ploughing in, while simultaneously obtaining significant organic mass, it is recommended to sow mixtures of legumes with other plants. The most valuable green fertilisers are obtained from mixtures of legumes with cereals. The species of plants included in the mixture should have similar soil requirements. On light to medium soils, a mixture of yellow lupine (140 kg/ha) with serradella (25 kg/ha); yellow lupine (120 kg/ha) with field pea (80 kg/ha) and serradella (20 kg/ha); yellow lupine

(120 kg/ha) with field pea (60 kg/ha) and mustard (60 kg/ha); field pea (150 kg/ha) with sunflower (15 kg/ha), or yellow lupine (150 kg/ha) with spring vetch (40 kg/ha) and oats (20 kg/ha) can be used. On heavy soils, for example, a mix of common vetch (120 kg/ha) with field bean (50 kg/ha) or field pea (120 kg/ha) with field bean (50 kg/ha) may be used. Depending on the soil and climatic conditions, the mixture composition and the proportions of components may be different than those given above.

The plants cultivated for green manure should be fed with mineral fertilisers. For legumes (except peas and field beans) the fertiliser requirements in relation to N are 10–20 kg/ha. For other plants intended for green fertiliser, doses of N vary from 50 to 100 kg/ha. The indicative doses of P and K are 30-50 kg P/ha and 50-100 kg K/ha.

Mineral fertilisation

Before planting trees, it is often necessary to use fertilisers/soil improvers containing phosphorus and potassium. The need for P and K fertilisation and the dose size depend on their content in the soil (Tables 2, 3).

Phosphorous fertilisers can be used both under forecrop and prior to planting. It is recommended that potassium-based fertilisers be used immediately before planting. Potassium fertilisation under forecrop shall only be justified if its high doses are applied in the form of chloride (potassium salt). Regardless, phosphorous and potassium fertilisers should be mixed with the soil to a depth of at least 20 cm.

Liming

Liming requirements depend on the current soil pH and its agronomic category (Tables 6, 7). It is preferable to apply lime one year before establishing the plantation. Performing this treatment too late makes it impossible to increase the soil pH to the value required for hazel (6.5–7.2), which may weaken its growth. When it is necessary to increase the pH and the content of Mg in the soil, magnesium lime should be used at a dose resulting from the need for liming.

On light soils, it is recommended to use lime in carbonate form, and on medium and heavy soils in oxide form (caustic lime) or hydroxide form (slaked lime).

4. Fertilisation in the first two years of running a plantation

If fertilisation was correct before planting the trees, in the first two years of the plantation it is limited only to N.

Depending on the organic matter content in the soil, the recommended N doses are 6–12 g/m2 (Table 5). These doses apply to plantations where mechanical fallow is maintained over the entire surface or in strips along the tree rows. If turf is maintained over the entire plantation area or if there is heavy weed infestation around the plants, N doses should be increased by about 50%. Doses of N should also be increased (by 30-50%) when rows of trees are lined with organic mulches with a high ratio of carbon to nitrogen (e.g. straw, bark, cuttings of branches).

In the first year of the plantation, nitrogen fertilisers shall be used twice. The first dose

of N, constituting about 30% of fertiliser needs, is spread in spring (in early April), and the remaining part (70%) – in early June. In the second year of tree growth it is also necessary to divide the annual N dose into two parts. The first dose of N, constituting 50–70% of the needs, is applied in spring, and the remaining part (30–50%) – in early June.

In the first two years after planting the trees, nitrogen fertilisers are spread in strips (1–1.5 m wide) along the row.

5. Fertilisation and liming on a productive plantation

5.1. Nitrogen fertilisation

Depending on the organic matter content in the soil, the recommended N doses for hazel plantations range from 40 to 100 kg per ha of fertilised area (Table 5). Nitrogen fertilisers shall be applied once in spring (in the first days of April). Fertilisers are spread in strips along the rows of trees.

5.2. Fertilisation with phosphorus

Phosphorus fertilisation shall be performed when soil analysis results show its low content in the soil (Table 2) or when symptoms of its deficiency appear on the plant. Phosphorus fertilisers are applied foliarly or spread/poured onto the soil surface along the row of plants (in this case, fertilisers containing, inter alia, polyphosphates should be used).

5.3. Fertilisation with potassium

If the soil was properly prepared before the plantation was established, potassium fertilisers are usually applied from the third year of plantation. The need to fertilise with potassium and the size of its dose is determined by the content of potassium in the soil (Table 3). Potassium doses given in the table refer to plantations where herbicide/mechanical fallow is maintained along rows of trees. If turf is maintained over the entire plantation area or if there is heavy weed infestation around the plants, the potassium dose should be raised by about 30-50%.

Potassium fertilisers are applied in the spring or in the autumn. Spring application is recommended for light soils, and autumn application for medium and heavy soils. Potassium fertilisers can be spread into strips of herbicide/mechanical fallow.

5.4. Fertilisation with magnesium

Application of magnesium fertilisers is justified 3-4 years after plantation, provided that the Mg content in the soil at the time of planting was adequate. Soil analysis determines the desirability of Mg fertilisation (Table 4).

Soil fertilisation with Mg is limited to strips along the tree rows with a width of 1.5 m. Magnesium fertilisers should be applied in early spring. If the plantation needs to increase the soil pH and Mg content at the same time, magnesium lime should be used. The doses of magnesium lime, the date and method of its application shall result from the needs of liming.

5.5. Micronutrient fertilisation

Under the soil and climatic conditions of Poland, symptoms of deficiency of certain micronutrients in hazel plantations are observed sporadically.

Table 1. Symptoms of mineral deficiency in hazel

Component	Symptoms
Nitrogen	The first symptoms of deficiency are visible on older leaves. The blades of leaves turn light green and then yellow. The shoots are thin and short.
Phosphorus	Leaf blades turn purple or burgundy. The shoots are thick and short.
Potassium	The first symptoms of deficiency are visible on older leaves in the form of chlorosis/necrosis on the edge of the leaf blade. Then the chlorosis/necrosis spreads in between the main nerves of the leaf. The necrotised edges of the leaf blade curl up. The leaves hang on the shoots for a long time.
Magnesium	The first symptoms of its deficiency appear on older leaves. Between the main leaf veins chlorotic spots are formed, which after some time turn into necrosis. The affected leaves fall during the summer.
Calcium	Symptoms appear on the youngest leaves in the form of chlorotic discolourations. The leaves are wrinkly and the leaf blade edges are frayed.
Boron	Nut binding is weak. With severe deficiency, the top leaves are chlorotic, narrow, brittle, with necroses on their edges.
Iron	The first symptoms appear on the youngest leaves as interveinal chloroses while the main veins stay green. In case of a severe deficiency, the shoot tips, or even the whole shoots, die.
Manganese	The first symptoms of its deficiency appear on the leaves in the middle of the shoot in the form of chlorosis between the main veins.
Zinc	Leaf rosettes form. The top leaves are small and narrow, and grow close to one another. In cases of a severe deficiency the shoot tips die back.

The desirability of supplying hazel with micronutrients should be determined by a visual assessment of the plants (Table 1). If symptoms of boron (B), iron (Fe), manganese (Mn) or zinc (Zn) deficiency occur on the plantation, fertilisation with a given element is justified. When microelement fertilisers are applied to the soil, their recommended doses for hazel plantations are: 1-3 kg B/ha, 20-30 kg Fe/ha, 10-15 kg Mn/ha and 5-10 kg Zn/ha. In the case of foliar feeding of hazel with micronutrients, the fertiliser dose must be in accordance with the instructions for its use.

5.6. Foliar feeding

Foliar feeding should be treated as a complement to soil fertilisation. This type of feeding is applied when a plant is not able to absorb and/or transport a sufficient quantity of an element to its organs/tissues when this particular element is the most needed.

5.7. Fertigation

This is a method of fertilisation that involves supplying plants with mineral nutrients through the irrigation system. With this fertilisation system, only fertilisers that are highly soluble in water are used. Doses of substances used for fertigation are several times lower than the doses recommended in the conventional use of fertilisers. Fertigation of hazel is carried out after the first days of April to mid-August. The best production effects shall be obtained with the combined use of fertigation with traditional fertilisation (using reduced doses of components).

5.8. Liming

If at the time of planting the trees the soil pH was suitable for hazel (6.5–7.2), liming should be performed after another 3–4 years. Lime doses depend on the agronomic category of the soil and its current reaction (Table 8). With periodic liming of plantations, plants are subject to fluctuations in soil pH which under certain conditions may weaken growth and lower the crops of plants. It is therefore better to keep the soil pH at the optimum level throughout the time the plantation operates. In order to stabilise soil acidity, approximately 300 kg of CaO per hectare should be used (having achieved an optimal pH beforehand).

Liming should be carried out early in the spring or late in the autumn. When liming in spring, lime is spread when the surface layer of soil is thawed and the trees have not yet produced leaves. Autumn lime application is best done between the end of October and the first half of November.

Table 2. Soil fertilisation with phosphorus (P) before establishing a hazel plantation and during its management depending on the availability of P in the soil* (Kłossowski, 1972 modified by Wójcik, 2021)

P abundance of the humus layer		
low	**optimal**	**high**
P content [mg kg-1]		
<40	40–80	>80
Phosphorus fertilisation before establishing the plantation [kg P2O5 ha-1]a		
100-150b	50-–100b	0–50b
Phosphorus fertilisation on the plantation [g P2O5 m-2]c		
10-–15	0	0

* P assimilability in soil determined by the Egner-Riehm method

a Phosphorus dose applied to the fertilised surface

b Reduced or increased phosphorus doses by 20% should be used when its content in the layer below the humus level is > 40 mg P kg-1 and < 20 mg P kg-1

c Use fertilisers containing polyphosphates without the need to mix them with the soil

Table 3. Soil fertilisation with potassium (K) before the establishment of hazel plantation and during its management depending on the K assimilability in the soil* and the granulometric composition (Kłossowski, 1972 modified by Wójcik, 2021)

Share of soil	**Abundance of K in the humus layer**

particles with a size of < 0.02 mm [%] in the earth part	low	optimal	high
<20	K content (mg kg-1)		
	<50	50–80	> 80
	Potassium fertilisation before plantation establishment [kg K2O ha-1]a		
	150-200b	100-150b	-
	Potassium fertilisation on the plantation [g K2O m-2]		
	8–10	5–8	-
20-35	K content (mg kg-1)		
	< 80	80–130	>130
	Potassium fertilisation before plantation establishment [kg K2O ha-1]a		
	200-250 c	150-200 c	-
	Potassium fertilisation on the plantation [g K2O m-2]		
	10–12	8–10	-
>35	K content (mg kg-1)		
	< 130	130–210	> 210
	Potassium fertilisation before plantation establishment [kg K2O ha-1]a		
	250-300d	200-250d	-
	Potassium fertilisation on the plantation [g K2O m-2]		
	12–16	10–12	-

Assimilation of K in soil determined by the Egner-Riehm method.

a The dose of potassium applied to the fertilised surface

b Potassium doses reduced or increased by 20% should be used when its content in the layer directly below the humus level is >50 mg K kg-1 and <30 mg K kg-1, respectively

c Potassium doses reduced or increased by 20% should be used when its content in the layer directly below the humus level is >80 mg K kg-1 and <50 mg K kg-1, respectively

d Potassium doses reduced or increased by 20% should be used when its content in the layer directly below the humus level is >130 mg K kg-1 and <80 mg K kg-1, respectively

Table 4. Soil fertilisation with magnesium (Mg) before establishing a hazel plantation and during its management depending on the assimilability of Mg in the soil* and the granulometric composition (Kłossowski, 1972 modified by Wójcik, 2021)

Soil particle of <0.02 mm content (%) in the earth fraction	Abundance of Mg in the humus layer		
	low	optimal	high
<20	Mg content (mg kg-1)		
	<30	30–50	>50
	Fertilisation with magnesium before establishing a plantation [kg MgO ha-1]a,b		
	80–100c	60–80c	-
	Magnesium fertilisation on plantation [g MgO m-2]		

	8–10	6–8	-
≥20	Mg content (mg kg-1)		
	<50	50–70	>70
	Fertilisation with magnesium before establishing a plantation [kg MgO ha-1]a,b		
	100-120d	80–100d	-
	Magnesium fertilisation on plantation [g MgO m-2]		
	10–12	8–10	-

* Mg assimilability in soil determined by the Schachtschabel method

a Magnesium dose applied to the fertilised surface

b Where the reaction of the humus layer is below the optimal value for a given plant species, magnesium lime should be used at a dose appropriate for the liming needs.

c Magnesium doses reduced or increased by 20% are used when its content in the layer directly below the humus level is >50 mg Mg kg-1 and <35 mg Mg kg-1, respectively

d Magnesium doses reduced or increased by 20% are used when its content in the layer directly below the humus level is >70 mg Mg kg-1 and <50 mg Mg kg-1, respectively

Table 5. Approximate nitrogen (N) doses for hazelnut plantations depending on the organic matter content in the soil*

Age of the plantation	**Organic matter content (%)**		
	0.5–1.5	**1.6–2.5**	**2.6–3.5**
	Dose of Nitrogen		
First two years	10–12**	8–10**	6–8
Subsequent years	80–100***	60–80***	40–60

*for plantations where herbicide/mechanical fallow is applied in strips along the rows of plants or over the entire surface

** N dose in g/m2 of fertilised area

*** N dose in kg/ha of fertilised area

Table 6. Assessment of the need for liming mineral soils depending on the agronomic category of the soil and its reaction (according to IUNG, 1986)

Liming requirements	**pH**			
	Agronomic category of the soil			
	Very light	**Light**	**Medium**	**Heavy**
Necessary	< 4.0	< 4.5	< 5.0	< 5.5
Needed	4.0–4.5	4.5–5.0	5.0–5.5	5.5–6.0
Recommended	4.6–5.0	5.1–5.5	5.6–6.0	6.1–6.5
Limited	5.1–5.5	5.6–6.0	6.1–6.5	6.6–7.0

Unnecessary	> 5.5	> 6.0	> 6.5	> 7.0

Table 7. Recommended doses of calcium fertilisers depending on the agronomic category of the soil and its reaction (according to IUNG, 1986)*

Liming requirements	**CaO dose (t/ha)**			
	Agronomic category of the soil			
	Very light	**Light**	**Medium**	**Heavy**
Necessary	3.0	3.5	4.5	6.0
Needed	2.0	2.5	3.0	3.0
Recommended	1.0	1.5	1.7	2.0
Limited	-	-	1.0	1.0

* the given doses should be applied only before establishing the plantation, preferably under the previous crop

Table 8. Single doses of lime used on the plantation (Kłossowski, 1972, modified by Wójcik, 2021)

Soil pH	**Agronomic category of the soil**		
	Light	**Medium**	**Heavy**
	Dose [kg CaO 100 m-2]a,b		
<4.5	17	20	30
4.5-5.5	10	15	20
5.6-6.0	5	8	15
6.1-6.5	-	5	10
6.6-7.0	-	-	5

a Recommended lime doses in a cycle of 3-4 years.

b Apply lime only to the herbicide/mechanical fallow strips along the plant rows

III. SOIL CARE AND WEED CONTROL

Prof. Jerzy Lisek,

1. A comprehensive approach to soil care and regulation of weeds

Soil maintenance comprises activities that maintain the soil in a condition that allows the planting of hazel trees or shrubs, improve the conditions of their growth and facilitate the necessary work on the plantation. The main objectives are to improve the structure, fertility and aeration of the soil, to improve the penetration of water into the deeper layers, to ensure the mobility of machinery, to remove weeds and to maintain the soil surface in a state that allows the efficient harvesting of nuts. Uncontrolled weed growth limits the

growth and yield of hazel. Weeds compete with hazel for water, nutrients and light; they have an unfavourable chemical effect (allelopathy), worsen phytosanitary conditions, which promotes the development of fungal diseases and pests, and make mechanised harvesting of nuts difficult or even impossible. On the other hand, weeds, as a basic component of synanthropic (accompanying) flora, also perform useful functions that are referred to as ecosystem (environmental) services. They are the basis of biological diversity. They provide food to bees and other pollinating insects. They reduce soil erosion, salinisation, and compaction as well as leaching of nutrients which is important for their proper recirculation in the environment. They have landscape qualities. In winter, weeds retain snow on the plantation which increases the moisture supply in the soil. They sequester (bind and store) atmospheric carbon dioxide, limiting its content in the air. Weed control includes a set of activities that keep their number at a sufficiently low level, which allows for good development and yielding of the crops. The greatest threat to the development of hazel is caused by the development of weeds in the period from April to July. In the later period - from mid-August to October, i.e. during the fall of nuts, weeds should be eliminated, because they interfere with the harvest of nuts located on the surface of the soil. In the hazelnut plantations, the method of maintaining the soil surface is closely related to the method of collecting nuts. On small plantations, manual harvesting prevails. On large plantations, the harvest is mechanised. Nuts are squeezed into the middle of the rows by rotary rake or brushes, and then sucked, separated and cleaned from impurities by special combines acting as a vacuum cleaner. The above process runs smoothly only in fallow land with a well-settled soil surface or a very low mown turf. The fallow can be mechanical or herbicidal. The best conditions for mechanisation of harvesting are provided by herbicide cutting, but in integrated hazelnut production it cannot be implemented on the entire area of the plantation. Herbicides should only be used in so-called herbicide belts with a maximum width of 3 m. In plantations where the harvest is carried out using shakers with a sheet fastened under the crowns of the hazel, the method of soil maintenance is not so important.

The grower's actions related to weed control should be proportionate to the threats and implemented as a previously planned, coherent programme. When establishing a plantation with integrated production and during its management, chemical methods of weed control (use of herbicides) and non-chemical methods are combined – mechanical treatments (soil cultivation, mowing of unnecessary vegetation), maintenance of cover plants, mulching and rarely used physical methods (e.g. burning weeds with a propane torch, treatment with hot water, hot steam, hot plate or electric current). Methods alternative to the use of herbicides must be used as a first resort. Herbicide spraying is recommended when alternative methods prove to be ineffective, difficult to implement or too expensive. Individual soil care methods are combined in various ways and used co-operatively (turf in the inter-rows and mulches or herbicides in the hazel rows), or in rotation (alternating use of different methods). An important element of protection is preventive measures, including weed control before the plantation is established, before the weeds produce their seeds,

and in the immediate vicinity of the plantation if their seeds are carried by the wind.

2. Chemical weed control methods

Before establishing a plantation, systemic foliar herbicides can be used to control perennial (permanent) weeds. The selection of herbicides varies, so at the beginning of each growing season it is necessary to check the status of the herbicides in terms of scope of registration and IP approval. If the herbicides currently recommended for IP plantations include soil-applied substances whose period of effective action in the soil during the plant vegetation period does not exceed three months, they may be used in the first three years of the plantation. The total dose of a soil herbicide during a year or the sum of doses - late autumn and spring, should not exceed the equivalent of the maximum recommended single dose. Herbicides are used regularly only in herbicide strips, the area of which should not exceed 50% of the total planting area. The width of herbicide strips depends on the spacing of planting, the age of the plantation and the form of hazel cultivation. With the most common spacing of 6 m between the rows, the width of the systematically sprayed zone should not be greater than 3 m. Depending on the harvesting technology, permanent herbicide strips can be maintained in the hazel line (trunk or shrub form) or in the inter-rows. Herbicide fallow is obtained by regular use of herbicides, in accordance with current recommendations for hazel plantations with IP. Foliar herbicides are most often applied in three basic periods: at the turn of April and May, in July and in autumn - in October and November, if the recommended products include those that work well at low temperatures. If no withdrawal period expressed in days is indicated on the label, the product should be used no later than one month before the nuts are harvested. Due to the limited number of herbicides registered for hazel, it is recommended that herbicides only play an auxiliary role in the plantation, in the control of particularly troublesome weeds, which include perennial species, e.g. field bindweed or couch grass. When using herbicides regularly, it is necessary to rotate (change) the agents with different mechanisms of action, which is becoming increasingly difficult. The scope and the way of application of chemical herbicides, including the maximum number of treatments per growing season, should comply with the products' labels. Herbicide spraying should take place under conditions and in a manner that shall help to achieve maximum potential efficacy. The optimal spraying effect is achieved by the correct selection of: the type of agent and adjuvant (booster), if one is recommended, doses, timing of treatment – taking into account the weed development stage and weather conditions, the volume of spray liquid and the spraying technique.

Plant protection products should be used in accordance with the recommendations given on the label and in a way that does not endanger the health of humans, animals or the environment.

The list of herbicides permitted in Poland is published in the register of plant

protection products. Information about the scope of pesticide use for particular crops is placed on the product's label. The plant protection product search engine (https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie is a helpful tool when selecting pesticides. Current information on the use of herbicides may be found on the website of the Ministry of Agriculture and Rural Development at https://www.gov.pl/web/rolnictwo/produkcja-roslinna.

The list of plant protection products for integrated production is developed by the Research Institute of Horticulture in Skierniewice and published in the Fruit Plant Protection Programme. A list of recommended plant protection products for IP is also available on the website of the Institute of Horticulture athttp://arc.inhort.pl/serwis-ochrony-roslin/ochrona-roslin/ochrona-roslin-rosliny-sadownicze.

Moreover, information on plant protection products used in integrated production is published on the Pest Signalling Platform at https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.html.

3. Mechanical methods of weed control

Mechanical weed control usually consists in systematic soil cultivation, and is usually carried out in the inter-rows of newly established and young plantations. The area maintained in this way is referred to as black or mechanical fallow.Soil cultivation during plant vegetation is carried out at different frequencies (from 10 days to four weeks), using tillers, cultivators, harrows or cultivation units with, for example, cultivator points, open cage rollers and finger weeders. Active rotovators, with blades installed on a rotating shaft, are very effective tools, but they quickly damage the structure of the soil, which leads to a decrease in organic matter content and fertility. Active rotovators have been increasingly substituted by self-propelled rotovators. Passive tools are preferred, with working elements such as tines, cultivator points and coulters (cultivator type), often combined with a string roller or disc harrows. Cultivations are carried out after a mass emergence of weeds, abundant rainfall and after the formation of the soil crust. During the growth season, soil cultivation should be shallow, to a depth of several centimetres. The number of treatments performed in spring and summer – until August should be limited to 4–6 treatments per season to limit soil degradation and erosion. When the mechanical fall improves the harvesting of the nuts, we make the last crop before the expected rainfall, no later than July, and we carefully balance the soil. On the plantation, you can use specialist tillers or other types of weeders, e.g. with undercutting blades placed on side arms that work under the hazel crowns. Automatic weeders with a tilting section ensure almost complete mechanisation of weeding in a row of cultivated shrubs. Another option is to use weeders that move the soil in a strip along the bush roots or trunk (depending on the form of hazel cultivation), aggregated with a large finger star (finger weeder), which destroys weeds in the line of planted plants. Turf is maintained between inter-rows. Mowing unnecessary vegetation is especially important in the second half of the summer to limit the spread of weed seeds. For work in rows of trees, grass trimmers (cutters) are intended, and their

cutting elements can be blades, strings, or scissors. Shallow mechanical cultivation and mowing do not effectively combat deep-rooting and creeping perennial weeds, like couch grass.

4. Ground cover plants

Ground cover plants, usually turf made up of perennial meadow grasses – red fescue (both in tuft and creeping forms), common meadow-grass and perennial ryegrass (English ryegrass), are the optimal way to maintain inter-rows on a plantation. Turf may consist of mixtures of the aforementioned species or mixtures of ecotypes (varieties) within one species, whether or not listed here, suitable for local conditions. Grass is usually sown in the third year after planting hazels and mown on average 4–8 times per season. From spring to August cover crops are mown when they reach about 15 cm in height. Before the nuts fall, the turf should be mowed as low as possible up to 1-2 cm high to facilitate nut harvesting. The frequency of mowing depends on the composition of the turf, weather conditions and the type of mowers – rotary, drum or flail-type. The lowest and rarest mowing is possible with flail mowers. The so-called natural sodding of the inter-rows is also allowed, especially if grasses develop in it, e.g. annual meadow grass and poorly growing dicotyledonous weeds, e.g. geraniums, daisies, speedwells, hawkweeds, umbellate, plantains, common yarrow. To reduce soil erosion, in hilly areas and on very fertile soils, turf is established in the first year of the plantation. In the case of mechanical fallow maintained in the inter-row areas to facilitate the harvesting of nuts, it is advisable to sow groundcover plants, e.g. winter cereals or legumes, in the autumn. They are mown in the spring and mixed with the soil as green manure. The most recommended from among legumes is the annual subterranean clover – Trifolium subterraneum L. Green fertilisation with the use of short-lived groundcover plants improves the soil structure and increases its organic matter content. Legumes are also an additional source of nitrogen.

5. Soil mulching

Unlike other fruit species, the implementation of mulches in hazel plantations is much more problematic. This is due to technical reasons, which are primarily related to the mechanisation of fruit harvesting. To reduce weed infestation in the hazel row, synthetic mulches can be used - black agrotextile or polypropylene non-woven fabric, black polyethylene foil, which are stretched on specially formed low ridges. The machines used to harvest the nuts, especially the rake or brushes that remove the nuts, will damage the mulch. These mulches can be recommended on small plantations, where nuts are collected with the help of shakers with a sheet stretched under the crowns of hazel, which is a solution rarely used. When introducing strips of synthetic mulches under hazel, it should be taken into account that machines working in the inter-rows - weeders and mowers - destroy the mulches in the area adjacent to the inter-rows. At the working width of the machines, less than the width of fallow or turf strips, in turn, there remains an uncultivated or uncut zone in which weeds develop. In order to avoid mechanical damage to the non-woven fabric

or foil, as well as weeding, herbicides are applied along the mulches in a 20-25 cm wide strip on the inter-row side. The lifespan of synthetic mulches is several years, after which they require troublesome disposal (collection and processing or burning in incinerators). Natural mulches – textile waste, cereal and rapeseed straw, sawdust, plant chips, tree bark, manure, brown coal, compost, fruit pomace are not suitable for large plantations with mechanized nut harvesting. To a limited extent, they can be implemented on young, newly planted and non-fruitful plantations in the arable plant belt or laid only around plants within a radius of up to 1 m, in order to improve the growing conditions of hazel and reduce the germination of weeds. Organic mulches limit soil trampling, balance soil temperature and humidity and, as they mineralise, provide plants with nutrients. Before using organic mulches rich in cellulose (straw, sawdust, bark), the layer of which should be systematically supplemented to a thickness of 5–10 cm, additional nitrogen fertilisation should be carried out, increasing the dose of this ingredient by about 1/3 compared to the standard recommended dose. Straw increases the risk of attracting rodents. Perennial weeds grow through organic mulches, and the need for their additional control by chemical or mechanical (weeding) means must be taken into account. In the season preceding the introduction of mechanised nut harvesting, organic mulches should be mixed with the soil and switched to another way of soil maintenance.

IV. PLANTATION CARE

1. Watering

Prof. Waldemar Treder

Hazel has moderate water requirements, but prolonged droughts significantly influence its growth and yield. In dry years, hazel grown on light soils needs regular irrigation, especially in the first years after planting. To provide plants with the appropriate amount of water in our climatic conditions, rainfall of 550–600 mm is necessary. Unfortunately, in many regions of the country, the amount of rainfall during the growing season is much lower. When selecting the installation, as well as the irrigation process itself, particular attention should be paid to water efficiency. The average irrigation needs of hazel in July are approximately 2.7 mm per day. Unfortunately, in extremely dry years, this can exceed 4 mm. Due to the highest efficiency of water use, it is recommended to use drip systems to irrigate hazel. On farms with adequate water resources, sprinkler systems can also be used.

Sprinkler irrigation

During sprinkler irrigation, the irrigated surface is sprinkled with high-flow sprinklers of at least several hundred litres per hour and with a large range - a spray radius of at least several metres. In hazel plantations we can use fixed sprinklers, portable sprinklers or drum

sprinklers. The nozzle diameter and the sprinkler spacing should be selected depending on the water source efficiency and the water pressure. In order to ensure uniform irrigation, the sprinkler spacing should be close to their range radius. In case of fixed and portable sprinklers, they should be placed above the surface of the plants on well stabilised, vertical structures made of steel or PVC. The frequency of irrigation depends on the size of the plants and the weather conditions, and individual water doses result from the depth of the root system and the water capacity of the soil (Table 9).

Table 9. Approximate maximum irrigation rates (in mm*) for hazel plantations grown on different soil types (for soil wetting up to 30 cm)

Clays	Sandy clays	Loamy sands	Sands with poor clay content
36	30	24	18

*- 1 mm = 1 l/m2 = 10 m3/ha

Sprinkling should take place in the morning, so that leaves can dry as soon as possible.

Drip irrigation

Due water management, drip systems are mainly recommended for irrigation of hazel plantations. The main element of the installation are drip lines, in which emitters (drippers) are placed inside polyethylene pipes during their production. The spacing of emitters in drip lines is selected so that the moistened soil clods touch each other. The humidified soil has an oval shape - the largest range of wetting is not on the surface of the soil, but at a depth of about 20 cm. On light soils, it is recommended to use drip lines with an emitter spacing every 30–40 cm and on heavy soils 50 cm. Drip lines on young plantations should be laid on the surface of the ground in the axis of the row. Drip lines on older plantations (over three years old) should be moved 10-15 cm away from the axis of the row. It is recommended that a second drip line is installed on the other side of the row on light soils from the third year of cultivation.However, it must be remembered here to take into account such a situation in the selection of the efficiency of the pumping and filtration system and the diameters of the water bus lines and collectors. It is also possible to submerge the drip lines below the soil surface at a depth of 5-15 cm. Placing drip lines under the soil surface increases the risk of emitters being blocked by plant roots, therefore only emitters for which the manufacturer in the technical specification ensures the resistance of installation to root ingrowth are used for deep irrigation. Due to the high sensitivity of drip systems to emitter clogging, the filter is a very important element of the installation. Table 10 contains information on the impact of water quality on the probability of drippers clogging up.

Table 10. Assessment of water quality for drip irrigation

Factors	Likelihood of clogging		
	small	medium	large
Solids content [mg/l]	<50	50-100	>100
pH	<7	7.0–8.0	>8.0
Manganese [ppm]	<0.1	0.1–1.5	>1.5
Iron [ppm]	<0.1	0.1–1.5	>1.5
Bacteria [number/ml]	10 000	10 000-50 000	50 000

The amount and type of filtration depends on the flow rate and water quality. When using water from open tanks, the use of sand filters is recommended. Groundwater can contain high levels of iron, so a water analysis should be performed prior to designing a drip installation. With an iron content above 1.0 mg/L it is advisable to use an iron removal device. The frequency of irrigation and water volume can be determined based on the measurement of moisture content or soil water potential. Soil moisture sensors or tensiometers are placed 15-20 cm deep, close to where the water is emitted. In the case of drip systems it is about 15 cm from a dripper along rows of trees. A single dose of water for a drip system should be selected so that the water does not penetrate below a depth of 30 cm https://ipwdn.inhort.pl/kalkulatory/nawadnianie-rosliny-sadownicze/zasieg-zwilzania-nawadnianie-kroplowe.

The legal provisions regulating the withdrawal and use of water for irrigation are included in the Water Law http://isap.sejm.gov.pl/. Every owner of an irrigation system is required to hold documentation confirming the right to use water resources.

2. Tree training and pruning

Grzegorz Hodun, Msc

The pruning of fruit trees is an exceptionally important agrotechnical procedure carried out throughout the whole period of their cultivation. Young trees are trained differently than old trees, because with age, the purposes of this treatment change. The training of young hazelnut trees serves to form the crown on a sufficiently high trunk. The aim of pruning older trees of this species is to keep them in good condition for as long as possible, to maintain good fruiting for many years, as well as to create the best conditions for fruit harvesting and plant care.

The first training of hazelnut trees, regardless of the date of planting, is always done very early in the spring. The way in which it is carried out depends on the quality of the plants and the planned method of both harvesting the fruit and the management of the trees. If the nuts are to be machine harvested, the trunk of the hazel must be about 80 cm high.

When the planted hazel trees are sufficiently high, it is necessary to trim the leader at the height of about 120 cm to form an approximately 80-centimeter trunk. As a result, several shoots will grow out of it, of which 4-6 should be left (the rest should be pruned

‘smoothly’). The remaining shoots should grow in different directions, sufficiently high above the ground and be at a distance of about 15 cm from one another. If two of them grow in a row or slightly diagonally, it will be possible to start forming a partially flattened crown, advised in the case of machine harvesting of nuts, in the first year after planting. If there are no such directed shoots, the formation of such a crown will move to the second year. The selected shoots growing in the direction of the inter-rows are then pruned about 50 cm from the leader behind its lateral branch that grows in the desired direction.

When machine harvesting is planned but the purchased trees are insufficiently grown, they are to be trained at the height of 30-50 cm from the ground after planting (early spring). As a result, they will grow to the right height by autumn, and some of them will branch out. If the branches are high enough, they should be left and used to form the crown the following year. If they grow too low, they should be pruned ‘smoothly’ in the spring of the following year. In the second year of vegetation, in early spring, the leader of sufficiently tall trees shall be cut at a height of about 120 cm from the ground. The next steps are the same as with the trees that were well-grown from the beginning. This method of pruning is sometimes also used in the case of trees sufficiently grown in the nursery (when the buds at the appropriate height are broken off).

A hazel plantation with high-trunk trees is easier to run than a plantation with low-trunk plants. When the tree trunk is 50–60 cm high (it may be like this when harvesting nuts by hand), it is more difficult to cut off the shoots and maintain the turf. Therefore, when establishing a hazel plantation for this type of harvest, it is also worth planting trees with a higher, about 80-centimeter trunk.

The correct formation of the crown of the hazel (the right number of shoots growing at the right height, appropriately directed) takes 1-3 years. For the next 3-4 years, if needed, only adjusting its shape should be done. Pruning during this time should be limited to the minimum necessary for the trees to start fruiting in the third or fourth year after planting (photograph 2).

Photograph 2. Correctly formed hazelnut tree

Fruiting hazelnut trees age more and more with each passing year. The signs of this, depending on the fertility of the soil and the intensity of the pruning after the trees start fruiting, begin to be visible between the sixth and eighth year of the use of the plantation. The trees then start to receive shoots of no more than 15 cm in length, on which the fruit is poorly bonded. In the middle and lower part of the crown, more and more shoots appear, which die due to lack of light. These symptoms mean the need to perform both crown thinning and rejuvenating pruning. Crown thinning will relax the crown, providing all shoots with fairly even access to light. Rejuvenating cutting will stimulate shoots to grow, as a result of which the share of long shoots providing good yields will increase in the crown. It is not worth postponing either of these forms of pruning, because it is always easier to shorten a branch that is not very strong than to cut out a thick branch. Furthermore, the removal of thick branches entails additional work and time to form replacement branches. It is advisable to lower branches in early spring, because the intended effect will be seen later in the same year, at the end of vegetation. Branches are cut in late summer, after fruiting, or in late spring if poor fruiting is expected in the pruning year. Older trees also require sanitary pruning, i.e. cutting bunches and shoots that are broken or dying, which constitute an open inlet of infection. Over time, on hazel plantations, it may be necessary to lower tree crowns and shorten or prune shoots entering the inter-row. In both old and young plantations, suckers should be removed to avoid unnecessary loss of nutrients and crown thickening.

V. PROTECTION AGAINST DISEASES

Dr Monika Michalecka, Dr Anna Poniatowska, Prof. Joanna Puławska

1. The most important diseases and their characteristics

Hazel Monilinia (caused by Monilinia spp. Honey) is a disease that affects the fruit cover, shells and nuts. Its first signs, in the form of dark brown, recessed spots, appear on the green covers of the buds, and as the buds grow, necrosis spreads from the cover to the shells, and then to light green and still soft nuts. Dusty, faint-yellow or gray papillae (sporodochia) of the conidial stage of fungi may appear on the surface of infested fruit-forms. Symptoms of the disease can be most easily noticed on varieties of hazelnuts, whose nuts have a short fruit cover. In long-grain varieties, sometimes the symptoms of moniliosis are visible only after the fruit cover has been torn. Affected nut buds tend to rot and fall prematurely. The source of the disease are mummified, overgrown with a compact layer of mycelium and fallen to the ground nuts, on which in spring in conditions of high humidity of the air, conidia shafts with spores form. During the season, secondary infections of the developing fruit-bearing species occur. Intensive spore formation of Monilinia spp. is promoted by temperature from 22°C to 27°C, which intensifies the epidemic occurrence of

nut moniliosis in hot and humid summers.

Gray mould (perpetrator Botrytis cinerea Pers.) on hazel is mainly found on the cover of fruit buds. As they grow, necroses spread to shells and light green, soft nuts. In conditions of high humidity, on the surface of infested nut cover may appear dark gray mycelium and dusty plaque of conidial shafts with spores. The growing fruit turns brown. The hallmark of B. cinerea on nuts are hard, flat clusters of mycelium, called sclerotia. In conditions of high relative air humidity and with high intensity of symptoms, large, necrotic, brown spots may appear on the nuts and leaves, and the tips of the shoots may die. The source of the disease are nuts with sclerotia fallen to the ground. In the spring, within the sclerotia, conidial shafts with spores are formed, which, after release, infect the green fruit cover. During the season, secondary infections of the developing fruit-bearing species occur. Intensive spore formation of B. cinerea is favoured by temperatures ranging from 15°C to 22°C and high air humidity (above 75%).

Powdery mildew (perpetrator Phyllactinia corylea (Pers.) P. Karst.) is rarely found on hazelnut plantations in Poland. The characteristic symptom of the disease is a white, floury mycelium coating on the underside of the leaf blade, which usually appears at the turn of spring and summer on the leaves in the lower parts of trees. The development of young leaves is inhibited. Heavily infected leaves turn brown, curl, dry out and fall off prematurely. The floury coating may also cover the shoots. In autumn, on the floury coating there appear black small fruiting bodies at the stage of an excellent fungus (peridium). The fungus winters on the fallen leaves of the hazel, on which it produces the fruiting bodies of the perfect stage - peridia with pouches. In spring and summer, spores are extracted from the peridia, which along with the wind are transferred to the developing leaves of hazel and infect them. During the growing season, many generations of conidia spores are formed.

Shoot cancer (perpetrator Cytospora corylicola) is common on hazel plantations in Poland (data from the Lubelskie and Świętokrzyskie Regions). On the shoots of weakened plants, the fungus can cause necrosis, taking the form of cracks and sunken carcinomas. In these places, under conditions of high air humidity, orange exudates appear containing conidia of the fungus. Severely affected shoots die. The fungus overwinters as spore mycelium in infected bark. In spring, in conditions of high air humidity, spores are released from the fungal fruiting bodies formed in the tumours, which, through injuries and damage to the bark, infect the original shoots of the hazel.

Bacterial gangrene of hazel (perpetrator of Xanthomonas arboricola pv. corylina) is commonly found on hazel in all areas of its cultivation in the world. Symptoms of the disease are observed on various organs of plants, causing the disappearance of buds, both leafy and floral, around which gangrene forms. Initially, they are small, slightly convex brown spots, often in the shape of an ellipse. When the bark has been removed, the brown tissue is clearly visible. These necroses increase over time and, in some cases, cover the entire circumference of the infested shoot causing it to die off. On the leaves there are large, oily, polygonal, brown spots, which are often surrounded by a light green discolouration. On fruits, both on the husk and on the fruit cover, irregular, initially hydrated, and then brown

spots and necroses are often visible. Young plants up to 3 or 4 years of growth are the most susceptible to bacterial gangrene. Individual shoots or even whole plants may then die completely. However, the most dangerous is the gangrene surrounding the entire perimeter of the trunk, which, even in the case of older plants, 8-10 years old, can lead to them dying off.

Hazel bacterial cancer (or dying of a hazel trunk) (perpetrator Pseudomonas avellanae) - is strongly associated with acidic soils with pH <5.0. The main symptom of the disease is sudden wilting of leaves, twigs, branches and the entire tree in spring and summer. The initial symptoms of infection can appear in winter during the flowering of male inflorescences. Infected inflorescences release only small amounts of viable pollen and often completely wither. In winter, the dead inflorescences remain firmly attached to the shoots. In February and March, female inflorescences on infested plants can have stunted growth and undergo necrosis. In spring, sick trees may show delayed bud burst, and the emerging leaves in particular branches can quickly wilt and die. In other cases, on trees or individual shoots without any previous signs of dying, leaves developing in early spring may be pale green. Such plants or individual shoots often wilt and die in summer. There are no symptoms of the disease on leaves and nuts. In autumn, cancers develop on the branches and trunk. The diseased bark becomes reddish-brown, and after its removal, brown discolorations are visible. Root rot may also occur. Infected plants that survive the winter often die over the next summer. It has also been shown that P. avellanae migrates systematically within the plant. Bacterial infection can result in longitudinal carcinomas on branches and trunks in summer and autumn.

2. Methods and dates of inspection

The severity of the diseases depends on the presence of pathogen sources and the atmospheric conditions. Observations of the occurrence of symptoms of moniliosis, gray mould, bacterial gangrene and bacterial cancer on hazelnuts should be carried out in the period from June to August, with particular emphasis on July and August, when the symptoms of diseases occur in the highest intensity, but before the mass subsidence of infested buds. Observations should be carried out at 3 to 4 different plantation sites every 10 to 14 days on a sample of 100 randomly selected fructification from 4 to 5 trees in 4 repetitions.

In the case of inspecting hazel plantations for the occurrence of powdery mildew, systematic observations of leaves should be carried out in the summer until the leaves change colour, especially in the lower part of the plants. In turn, inspections for the presence of shoot cancer, observations of exudates (sac spores, then conidia) in bark cracks, especially in shoot forks, should be carried out from the beginning of vegetation.

3. Methods of disease prevention and non-chemical methods of plant protection against diseases

Studies show that the better the condition of the hazel, the less susceptible it is to infections. Healthy planting material, rational irrigation and fertilisation – especially nitrogenous and properly managed agro-techniques, including well-run and sanitary crown thinning, as well as appropriate weed control, ensuring good ventilation and rapid drying of aerial parts of plants, play a key role in preventing the development of diseases. Cutting or raking and removing infected shoots, leaves, fruit buds and nuts from trees and their vicinity limits the source of infection in the next season, thus reducing the risk of infection.

The pruning of shoots with symptoms of diseases (necrosis, gangrene, carcinoma) should be carried out 60-100 cm below the lower limit of necrosis. During pruning, the tools should be disinfected (between each cutting, the tools should be immersed in 70% ethanol). In addition, as far as possible, it is important to remove wild trees and shrubs from the vicinity of the plantation, which are hosts of the perpetrators of hazel diseases. The planting density and the method of managing hazel should ensure the quickest possible drying of the above-ground parts of the plants, because prolonged wetting favours infection and the development of diseases. Care should be taken to ensure an appropriate pH of the soil, which should be between 6.0 and 7.2.

4. Chemical pathogen control

The control of hazel moniliosis with allowed fungicides should be started at the end of June and repeated several times, especially in periods of humid weather. There may be changes in the selection of products approved for use every year. Conservation measures should always be applied in accordance with the label – instructions for use indicating the extent of the crops and pests against which the product may be applied, as well as the dose, grace and prevention periods and other comments on the conditions of use.

The list of plant protection products allowed in Poland is published in the register of plant protection products. Information about the scope of pesticide use for particular crops is placed on the product's label. The search tool for plant protection products is a tool to help select pesticides. The register, labels, and search engine of plant protection products are available on the website of the Ministry of Agriculture and Rural Development at https://www.gov.pl/web/rolnictwo/ochrona-roslin and https://www.gov.pl/web/rolnictwo/wyszukiwarka-srodkow-ochrony-roslin---zastosowanie.

The list of plant protection products for integrated production is being developed by the Institute of Horticulture – National Research Institute in Skierniewice and published in the Plant Protection Products Programme. The list of plant protection products recommended for IP is also available on the website of the Institute of Horticulture – National Research Institute at http://arc.inhort.pl/serwis-ochrony-roslin/ochrona-roslin/ochrona-roslin-roslinysadownicze/rosliny-sadownicze-wykaz-srodkow.

Information on plant protection products for integrated production is also provided on

the Pest Alerting Platform at https://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanejprodukcji.html.

Plant protection products should be used in accordance with the recommendations provided on the label and in a way that does not endanger the health of humans, animals or the environment.

5. Timing and conditions of application of fungicides

The effectiveness of chemical protection should be determined by compliance with the recommended dose of the product and the accuracy of the procedure. When using surface-applied products, it is necessary to take into account the possibility of washing away the product used (rainfall recording) and the rate of tissue growth, e.g. leaves and shoots. When selecting fungicides, it is also worth paying attention to the spectrum of their action and the possibility of performing one procedure against several diseases. Temperature observation during plant protection treatments is particularly important in early spring when it can get cold during which the selected product does not work. The optimum temperature for fungicide treatments usually ranges from 12 to 20°C. If, for example, it is too low, their effectiveness may drop significantly, and agents applied in such conditions are characterised by a slower chemical reaction rate and a slower course of physiological processes in the plant cell. Therefore, it is mandatory to conduct and record measurements of daily precipitation throughout the period of use of plant protection products and to record temperature values immediately before and after each protection procedure. Due to the possibility of selecting resistant forms of some pathogens, e.g. Botrytis cinerea, fungicides from individual chemical groups, especially those with a specific mechanism of action, should not be used more often than twice a season, in rotation with preparations with a different mechanism of action, if available.

VI. PROTECTION AGAINST PESTS

Dr Michał Hołdaj, Damian Gorzka Msc, Dr Małgorzata Sekrecka

1. List of the most common pests and their characteristics

On the hazel, damage of greater economic importance may be caused by spider mites, leaf rolls (mainly rose tortrix), aphids, nut weevil and the filbert bud mite. Locally the following may also appear: European fruit lecanium, Maybeetle and the Lucerne weevil.

Hop spider mite (Tetranychus urticae Koch) is a small, multi-eating mite commonly found throughout Poland. Its body is oval, about 0.5 mm long, with four pairs of legs. The overwintering females are brick-orange, and the summer generation is yellow-green with two darker spots on the sides. Males are slightly smaller than females and rhomboid in

shape. Larvae are smaller than adult mites, yellow-green, with 3 pairs of legs. Eggs are spherical, about 0.13 mm in size, yellowish. In early spring, on the first leaves that appear, hibernating female spider mites can be seen. All the moving stages of spider mites feed on the lower side of the leaf blade, sucking the juices from the cells. Yellow discolouration appears at the feeding site, visible on both sides of the leaf blade. Severely damaged leaves turn brown over time, dry out and shed prematurely. Feeding of spider mites weakens the growth and fruiting of trees. The inhabited plants are less resistant to frost and the fruits are of lower quality.

Hazel spider mite (Eotetranychus coryli) is a common pest in our country, but it occurs rather sparsely. The female, greenish in colour with several spots on the sides, is about 0.3 mm in size and slightly larger than the male. The eggs are spherical, glassy-white or light cream. The larvae are similar to adults, but smaller than they. The spider mite feeds on the lower side of the leaves in numerous colonies. The harmfulness of this species is similar to that of the hop spider mite described above.

Filbert bud mite (Phytoptus avellanae) is a leaf blister mite commonly found in Poland. The female is worm-shaped, with two pairs of legs on the front of the body, about 0.25 mm long. The male is similar to the female, but slightly shorter than the female. The egg is oval, shiny, size 0.02 mm. Leaf blister mites winter in the buds of hazelnuts. In the spring, when the bud sticks relax, the pests spread to other buds. Migration is protracted over time and can last between 30 and 50 days. As a result of feeding, the mites interfere with the normal development of the buds, causing them to grow excessively. Yield losses resulting from the feeding of the bud mite depend on the size of its population on the plantation and can reach up to 20-70%.

The rose tortrix (Archips rosana) belongs to the order of butterflies. The butterfly, a male, has wings spanning 16-19 mm, light brown to purplish brown in colour, with dark markings. The wings of the females are lighter, olive-brown, with a span of 19-24 mm. The eggs are flat, oval, approximately 0.5 mm in size, laid in grey-shaped beds of approximately 5–6 mm in diameter and covered by female secretion. The caterpillar is yellowish-green with a black head, the older one is green, darker on the dorsal side, with a dark brown head and grows up to 22 mm. At the end of summer, during autumn and winter, on the bark of hazel shoots you can find wintering rose tortrix roll eggs in beds. Caterpillars hatch in the last days of April or the first days of May and feed on the leaves, causing them to curl up, which provides protection for them. Caterpillars bite out holes and turn the leaves into skeletons; they can also damage fruit buds. They feed until June, then pupate on or between leaves. The butterfly starts to fly in the second half of June and July. During this time, females lay eggs, about 250 each.

The Maybeetle (Melolontha melolontha L.) is a beetle with a cylindrical body, 20-25 mm long, black in colour. The first pair of wings (lids), feelers and legs are brownish-brown. Rows of triangular white spots are visible on the sides of the black abdomen. The eggs are yellowish, the size of a grain of millet, and are laid into the soil in deposits of 25-30 eggs. The larva (called a grub) is initially whitish, then creamy, bent into a horseshoe shape,

with a large brown head and three pairs of legs. At the end of development, grubs reach a length of up to 50 mm. The beetles damage the leaves and, when they are abundant in number, can cause total destruction of leaves. The larvae of the beetle feed on the roots of plants, which is especially dangerous for young plantings. Damaged plants are weakened and, with a high incidence of grubs, roots are destroyed, plants wither and even dry out.

Lucerne weevil (Otiorhynchus (Cryphiphorus) ligustici) is a beetle that is common in Poland. The beetle is 12-15 mm in size, with a short, thick snout, dark in colour but covered with lighter hairs. The larva is white-cream with a brown head and grows up to 10 mm. The beetles and larvae spend the winter in the soil. In the spring, the beetles feed on the leaves of plants and lay eggs to the soil. Hatched larvae feed on the roots of the plants, thus weakening their growth and fruiting.

Nut weevil (Curculio nucum) is an 8-9 mm long beetle that is common throughout Europe. Its olive-brown body is finished with a long snout. The egg is oval-shaped, white. Yellowish larvae with a brown head grow up to 12 mm. Beetles in cultivation appear from the end of May, when the fruit buds reach a size of about 10 mm and are still soft. Females place eggs in the interior of the fruit and after approximately 7 to 10 days larvae hatch from them. At the end of August, the larvae bite a hole in the fruit through which they escape to pass the further cycle of development in the soil. They bury themselves in it to a depth of about 25 cm and spin cocoons in which they winter. In the spring, after pupation, the now adults leave the place of wintering. Direct damage is caused by larvae that feed in the interior of the fruit. Indirectly, by damaging the buds during egg laying, they can cause the trees to become inhabited by a pathogenic fungus leading to e.g. moniliosis of hazelnut.

The hazel aphid (Corylobium avellanae) and the ornamental hazel aphid (Myzocallis (Myzocallis) coryli) are small bed bugs quite commonly found on hazel in varying degrees. The hazel aphid is between 1.5 and 2.7 mm long and slightly larger than the ornamental aphid. Both species are light green in colour and have red eyes, but the hazel aphid has much longer siphons than the ornamental hazel aphid. The eggs are black elongated and the larvae are similar to adults, but smaller than them. The harmfulness of both species is the same. By feeding, they suck the plant juices and starve the plants out of the nutrients. Moreover, they excrete a large amount of liquid excrement, called honeydew, which covers the plant, and 'dibble' moulds develop on these secretions. Assimilation is weakened, growth is inhibited, and susceptibility to frost in plants is increased.

The European fruit lecanium (Parthenolecanium corni) is a small bug belonging to the Parthenolecanium family. The female bug is convex, hardened, hemispherical, brown, with a diameter of 3-7 mm. The male is winged, smaller than the female. In late May and early June, females lay eggs (white, oval, tiny, up to 600 pieces under a cup-shaped brown shield on the shoots). Young larvae have an oval cup, flat, greenish-white, later greenish. The larvae hatch in June and July and begin feeding on the leaves. After hatching larvae, the cups of the female usually fall off, leaving white marks. Both females and larvae feeding on shoots and leaves puncture them and suck out the plant juices. Damaged plants bear less fruit and, when infested in large numbers by larvae, even dry out. The sweet, sticky excretions of the feeding individuals cover the leaves and shoots, and 'sooty' fungi develop on it. Stage II larvae overwinter moving onto hazel shoots in autumn.

2. Risk thresholds and plantation inspection methods and dates

In order to correctly determine the need and timing of eradication, it is necessary to conduct visual inspection of trees on several occasions, and to estimate the level of risk by pests on the basis of an assessment of the number of species and their developmental stages (Table 11). In the hazel, it is mandatory to monitor the abundance of spider mites, aphids, filbert bud mite, rose tortrix and the nut weevil.

In plantations where pests have occurred in large numbers before flowering, eradication procedures should be carried out immediately. Protective treatments carried out before plant flowering often enable keeping the pest population low during the remaining part of the growing season. At the same time, the timing of treatments before flowering has a lesser impact on the reduction of the population of beneficial fauna, which at this time is not as numerous as during and after the flowering of the plants. There are currently no established threat thresholds for many hazelnut pest species.

Table 11. Dates and methods of plantation inspection for the presence of hazel pests

Pests	**Time of inspection**	**Inspection method and sample size for a plantation with a maximum area of 2 ha**	**Risk thresholds (on average more than)**
Hop spider mite	Prior to flowering		2 spider mites per leaf.
	After flowering, until harvest, every 2 weeks	During each observation, determine the number of pests in 200 randomly selected leaves (hazard thresholds similar to that of the currant were proposed).	3 spider mites per leaf
	After harvest		5 spider mites per leaf
Hazel spider mite	The inspection is carried out throughout the season, controlling at the same time the presence of the hop spider mite	At each observation date, determine the number of pests on 200 randomly selected leaves.	Not prepared
Rose tortrix	Leafless period in pre-spring or early spring	Look through 200 randomly selected shoots in search of overwintering eggs in deposits.	Not prepared
	At the end of April and in May	Look through 200 randomly selected tops of shoots looking for	

		leaves curled by caterpillars.	Not prepared
Filbert bud mite	Inspection for the presence of the pest should be carried out in autumn or early spring	Look through 200 randomly selected buds from plantations or all buds on 4 branches from 10% of trees per hectare.	15% of buds inhabited
Maybeetle	Checking for the presence of grubs should be carried out before planting.	In spring or summer, take soil samples from 32 randomly selected sites (holes, 25 cm x 25 cm and 30 cm deep = 2 m2 of the field surface area).	Before establishing the plantation - 1 grub per 2 m2 of field area
	When running a plantation, from spring to autumn	Wilting and poorly growing plants should be inspected for the presence of grubs feeding on roots.	Not prepared
Lucerne weevil	Before establishing the plantation.	Of 32 holes, with dimensions: 25 x 25 cm (30 cm deep) = 2 m2 take soil samples and check for the presence of pest larvae.	Not prepared
	During the growing season	Inspect the appearance of leaves by checking the presence of weevil larvae on the roots of wilting plants.	Not prepared
The nut weevil	Beetles on trees can be observed from May to June	During this period, they can be shaken from 35 randomly selected trees per area of 1 ha per entomological sheet. This should be done early in the morning. In June, you can view fruit buds damaged when eggs are laid in them.	Not prepared
	Towards the end of August and in September	Examine fruits, 3-4 samples of 100 fruits from 1 ha, to determine the presence of larvae in them.	Not prepared
Hazel aphid, ornamental hazel aphid	Since no hazard thresholds have been developed so far, inspection should be carried out throughout	Inspection consists of a regular inspection of plants in search of live colonies of aphids or damage caused by them.	Not prepared

	the season		

3. Non-chemical methods of protecting hazel against pests

In integrated plant production, priority is given to non-chemical methods of protection, which include both preventive and intervention methods:

- Before establishing a plantation, it is necessary to mechanically process the soil several times and grow plants that hinder the development of grubs, such as buckwheat or mustard.
- Establishment of plantations only from healthy nursery material, free of pests.
- In autumn, winter and early spring it is recommended to cut shoots that have been damaged by pests.
- To protect hazel against leaf-eating caterpillars, including leafrollers, you can use registered biological products containing the Bacillus thuringiensis bacteria.
- It is important to create favourable conditions for beneficial insects, mites and other arthropods through the installation of field trees, shrubs.
- If there is a balance in the hazelnut growing ecosystem, it is readily populated by various species of beneficial mites of the Phytoseiidae family which can effectively control the development of the pest or pest mite population.
- An important element of maintaining biodiversity in the surroundings of hazel groves is also the presence of birds, such as tits, tree sparrows or starlings. During the breeding season, they feed their chicks with various species of insects, which is why it is recommended to install nesting boxes designed for these species of birds.
- For the control of aphids, spider mites and coccids, it is recommended to use preparations supporting protection with mechanical or physical action, such as silicone compounds or polysaccharides, which create physical barriers, limiting the development of pests. The use of these types of preparations reduces the possibility of the formation of breeds resistant to pests to certain active substances of chemical agents. If such products are available, at least one treatment should be carried out with such a product.

4. Chemical protection of hazel against pests

- In the protection of hazel against pests, the use of currently registered chemicals is recommended, in accordance with the recommendations on the labels. In order to avoid resistance of pests to the active substances of insecticides and acaricides, a rotational use of preparations with different mechanisms of action is necessary. The maximum number of sprays against the pest concerned and the number of treatments with preparations containing a specific active ingredient must also be respected.
- The list of plant protection products authorised for use in Poland is published in the register of plant protection products, and details of their use in individual crops can be found on the labels. A search engine for plant protection products can also be helpful when choosing pesticides. The register, labels and search engine are available on the websites of the Ministry of Agriculture and Rural Development: https://www.gov.pl/web/rolnictwo/ochrona-roslin and

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

- Every year, the Institute of Horticulture – National Research Institute in Skierniewice prepares a list of plant protection products for integrated production, published in the Fruit Plant Protection Programme. The list is also available on the website of the Institute of Horticulture: http://arc.inhort.pl/serwis-ochrony-roslin/ochrona-roslin/ochrona-roslin-rosliny-sadownicze/rosliny-sadownicze-wykaz-srodkow.
- Information regarding plant protection products for integrated production may also be found on the Pest Signalling Platformhttps://www.agrofagi.com.pl/143,wykaz-srodkow-ochrony-roslin-dla-integrowanej-produkcji.html.
- Plant protection products should be used in accordance with the recommendations provided on the label and in a way that does not endanger the health of humans, animals or the environment.

5. Protection of beneficial arthropods and their introduction

Improper use of plant protection products can be harmful to pollinators and cause them to be poisoned or destroyed. This is mainly the case for zoocides and, to a lesser extent, fungicides.

In field conditions, the most common cause of bee poisoning is direct contact with the product. Poisoning also occurs when poisoned food (pollen, nectar, honeydew) is taken by bees and carried back to the hive. The entire bee family and the honey produced by it may then be poisoned.

In order to protect pollinators, the following principles shall be followed:

- use plant protection products only where necessary;
- carry out plant protection treatments only with products registered for the given crop and pest species;
- observe provisions for the use of plant protection products on the label;
- do not use unrecommended mixtures of plant protection products;
- correctly select the date of the treatment and the dose of the product used;
- do not use plant protection products on plants covered with honeydew, and if necessary, choose selective products and observe the prevention period;
- plant protection products (mainly insecticides) must not be used during the flowering of plants, weeds and other vegetation surrounding the crops;
- if it is necessary to spray orchard plants during flowering, the treatment should be carried out before evening, after the bees have flown away, using products with a precautionary period of not more than 6 hours;
- remember about the correct technique of the treatment;
- treatment with plant protection products is carried out under conditions that prevent the operating liquid from drifting to adjacent crops.

An important element is the establishment of houses for mason bees and nesting boxes for bumblebees. For mason bee houses, there should be at least 200 nesting channels

in the structure,with a diameter of 5-8 mm and a length of 14-20 cm. At least 70% of the nesting material (nesting channels) should be cut up cane tubes. The other material used for the shelters may include other cut plant stems with a hollow section, or drilled blocks of wood with the above-mentioned parameters.

For bumble bees, it is recommended that roofed wooden nesting boxes measuring approximately 20x15x10 cm with an entrance hole of 2 cm in diameter be displayed. Inside the box, material should be provided for the construction of an external nest, e.g. worn dry grass. Boxes can be placed on the ground, above the ground or by creating 'mounds' i.e. burying boxes halfway into the ground. The entrance to the nest should be easily accessible, not overgrown or obscured. The preferred place to set up boxes is the edge of the plantation. The number of mason bee 'houses' or bumblebee mounds should be at least 1 per 5 ha, or several in the case of larger plantations.

Among the enemies of natural pests on the hazel, the most common are beetles and ladybug larvae (Coccinellidae), chrysopid larvae (Chrysopidae), gall midges (Cecidomyiidae), pirate bugs (Anthocoridae), flies of the hoverfly family (Syrphidae). They are effective predators of aphids and mites.

Parasitic Hymenoptera (parasitoids) from the Ichneumonidae and Chalcididae families play a big role in reducing the number of harmful butterflies.

Caring for beneficial organisms manifests itself in the rational creation or protection of already existing habitats in which they live, reproduce and winter (e.g. clumps of shrubs, sowing flowering plants) and in the use of plant protection products that are selective or partially selective for beneficial fauna.

Insectivorous and predatory vertebrates play an important role in reducing certain pest species. Harmful rodents are reduced by predatory mammals such as martens, weasels, polecats, therefore it is worth creating good living conditions for them on plantations, e.g. by placing small piles of stones on the edges of the plantations. In turn, birds (including tits, owls, woodpeckers, birds of the hawk family, falcons) reduce populations of many harmful species of insects and rodents. It is therefore important to have refuges (trees, shrubs, water reservoirs) in the surroundings of the plantations, which are natural habitats for these animals. It is also necessary to install resting poles for birds of prey, at least 1 per 5 ha, or several in the case of larger plantations.

VII. RULES AND PRINCIPLES OF GOOD PRACTICE FOR HANDLING PLANT PROTECTION PRODUCTS (PPP)

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Plant protection with chemical products poses specific risks to the operator and the environment. In order to minimise the risks arising from their use, the treatment contractor must have appropriate authorisation to use plant protection products and use them skilfully, with special care, always in accordance with the law and the provisions of the label-

instructions for use, and with the use of technically efficient and calibrated equipment for treatments. Personnel and equipment authorisations and the procedures for handling plant protection products, particularly regarding activities performed before and after the treatment, are laid down in the provisions of the regulations of the Ministry of Agriculture and Rural Development. They are complemented by the principles of Good Plant Protection Practice.

1. Obligations of the user of plant protection products

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

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

To ensure the correct application of crop protection products, the sprayer must be calibrated. This is a legal obligation for sprayer users, who can and should carry out the calibration themselves. Although the regulations do not specify how often it should be repeated, it is good practice to calibrate the sprayer at least at the beginning and in the middle of the plant protection season. It is also worth documenting the calibration in the form of a record of assumptions and results of subsequent operations. The calibration process is described in one of the following subsections.

Treatments with plant protection products shall be recorded.

In accordance with Article 67(1) of Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 (OJ EU L 309, 24.11.2009, p. 1), owners of agricultural holdings are obliged to keep records of treatments carried out with chemical plant protection products. Records must contain information such as: the name of the crop grown, the area cultivated on the holding, the size of the area and the date of the treatment, the name of the plant protection product used, the dose of the product, and the reason for using the 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. The rules for documenting plant protection treatments will change on 1 January 2026 as a result of the application of the provisions of Implementing Regulation (EU) 2023/564.

2. Safety for the operator and the environment

Any handling of plant protection products poses a risk to the health of the operator. Therefore, when carrying out such tests, personal protective equipment should be used, i.e. protective clothing made of non-absorbent material, rubber boots with trouser legs let out over the tops of the boots, nitrile or neoprene gloves designed for working with chemicals, extending past the wrists and hidden in the sleeves of the suit, and safety glasses or a face shield with a transparent screen. When measuring plant protection products and preparing a spray liquid, the operator is particularly exposed to direct contact with concentrated preparations. Therefore, during these operations, one should additionally use: a rubber or foil apron covering the torso and legs, goggles tightly protecting the eyes, headgear, and a half-mask with a P2 dust filter for loose preparations or with an A2/A3 absorber for liquid preparations.

The spraying process, even with the use of an efficient and calibrated sprayer, causes the drift of the spray liquid, which in turn creates a risk of contamination of sensitive objects, such as surface water, apiaries, or other non-agricultural areas. In order to prevent this risk, it is necessary to maintain the buffer zones (protective zones) indicated on the labels between the place of application of plant protection products and sensitive facilities. Labels may also indicate the possibility of reducing the buffer zone if drift-reducing equipment is used to a certain extent. The classification of drift reducing techniques (DRT) is available on the IO-PIB https://www.inhort.pl/serwis-ochrony-roslin in the Plant Protection Technology tab. If there is no information on the buffer zone on the label of the plant protection product, general provisions on minimum buffer zones should be applied: for public roads, excluding municipal and district roads - 3 m; for apiaries - 20 m; for reservoirs and watercourses and non-agricultural areas - 1 m in the case of field sprayers and 3 m in the case of fruit sprayers.

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

The greatest threat to the environment, especially water, is local pollution caused by leaks or dispersion of concentrated plant protection products during their storage and preparation of the operating liquid, as well as the lack of the possibility of safe management of residues after treatments, i.e. residues of the working liquid, water after rinsing the liquid system and external washing of sprayers. They may also arise as a result of non-compliance with the rules for handling empty packaging after the products. The provisions concerning the storage of plant protection products, preparation of the spray liquid, washing of the sprayer and management of liquid residues are laid down in the Regulation of the Minister for Agriculture and Rural Development on the management and storage of plant protection products (Journal of Laws 2013, item 625). The Regulation imposes a general requirement to act in a way that reduces the risk of contamination of surface water, groundwater and soil,

which directly translates into the reduction of local pollution.

3. Storage of plant protection products

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

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

The labelling of plant protection products imposes additional requirements to guarantee their durability and effectiveness. For this purpose, the products should, as a rule, be stored at a temperature no lower than 0 °C and no higher than 30 °C, in dry, cool and properly ventilated places. They should be protected from moisture and direct exposure to heat sources.

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

be displayed in a visible location at the entrance to the facility.

In farms that employ workers, it is required to follow the Regulation of the Minister for Agriculture and Rural Development of 24 June 2002 on health and safety at work in the use and storage of plant protection products and mineral and organic-mineral fertilisers (Journal of Laws 2002, No 99, item 896).

4. Preparation of the usable spray liquid

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

$$Product\ quantity\,[L, kg] = \frac{Product\ dose\,[L, kg/ha]\ x\ Liquid\ volume \in the\ tank\,[L]}{Dose\ of\ liquid\ ¿¿¿}$$

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

The preparation of the spray liquid in the field, each time in a different location, prevents the accumulation of concentrated substances at a single point due to accidental, even minor, but difficult-to-avoid leaks. These minor leaks or scattering of substances onto the biologically active substrate of the field undergo natural biodegradation, minimising the risk of local contamination. For the safe preparation of liquids in the field, a preparation diluter is used, which is an additional device of the sprayer. Using a diluent, a concentrate of the plant protection product is prepared based on a small amount of water from the tank. This concentrate is then drawn into the main tank by means of ejection and mixed with

water. Empty packaging is rinsed using a pressure washer equipped with a diluent. In order to improve and maximise the safety of the entire process, it is advisable that the sprayer be also equipped with a storage compartment for plant protection products, empty packaging, a measuring cup for liquid preparations, and a clean water tank for washing hands. N.B.: the use of a diluent does not eliminate the need for the operator to use personal protective equipment.

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

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

5. Washing the sprayer

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

For efficient washing of the liquid system in the field, an additional water tank and a pressurised sprinkler are required to flush the tank. Internal washing of the sprayer is usually carried out in three cycles by successive dilutions of the residues of plant protection products. Half of the additional reservoir water is used for the first dilution, and 25% for

each of the next two. After each dilution, the contaminated water should be sprayed in accordance with the above-mentioned provision of the Regulation. The sequential dilution method shall ensure that, at the end of the operation, the concentration of the active substance in the water remaining in the sprayer system is not more than 2% of the initial concentration of the spray liquid. Due to the substances flushed from the sprayer during external washing, the provisions of the Regulation of the Minister for Agriculture and Rural Development specify a minimum distance of 30 m between the washing site and wells, water intakes, reservoirs, and watercourses. This requirement does not apply to washing facilities for plant protection equipment that meet certain technical requirements (a hardened surface made of impermeable concrete, a sealed mud and grease trap, and a sealed sewage tank).

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

6. Packaging

Packages of plant protection products classified as hazardous substances (marked with the pictogram GHS 06: Health hazard – Acute toxicity 1, 2, 3, or GHS 09: Hazard to the environment – Toxicity to the aquatic environment) are hazardous wastes that are subject to special treatment as defined in the Packaging and Packaging Waste Management Act (consolidated text: Journal of Laws 2024, item 927). The provisions of the Act impose on the users of these means the obligation to return the packaging to the seller, and on the sellers the obligation to accept this packaging and direct it for safe disposal. The label instructions indicate whether the packaging is to be treated as hazardous waste. If it is hazardous waste, the emptied packaging must be rinsed three times with water, and the rinsate poured into the sprayer tank with the utility liquid. Instead, a packaging scrubber may be used, but in that case, the pressure rinsing shall not take less than 10 seconds. Rinsed packages must be collected in specially marked plastic bags and returned to the seller in this form. The label prohibits the burning of packaging on one’s own and its use for other purposes, including as secondary raw materials. Labels of plant protection products not classified as hazardous substances include information on treating packaging as municipal waste. In this case, the incineration of packaging is still prohibited. After rinsing, depending on the type of

packaging, they can be placed in a plastic or paper container.

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

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1. Weather conditions

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

categories of weather conditions are shown in Table 12.

Table 12. Characteristics of weather conditions during plant protection treatments

Conditions	OPTIMAL	FAVOURABLE	ACCEPTABLE
Air temperature [°C]	6–15 *	up to 20	up tp 25 **
Air humidity [%]	60–95	over 50	over 40 **
Wind speed [m/s]	0.5–1.5	up to 2.5	up to 4.0 ***
Recommended droplet size	SMALL AVERAGE	AVERAGE THICK	THICK VERY THICK

* *when combating pests min 12-15 oC*

** *according to good practice*

*** *according to the law (Regulation of the Minister for Agriculture and Rural Development of 31.03.2014 – Journal of Laws 2014, item 516)*

2. Spraying technique

Spatial spraying of crops, such as hazelnut orchards, should be carried out with the aid of an auxiliary air stream. Due to the size and spacing of hazel trees, it is necessary to use high-performance sprayers, such as a standard orchard sprayer with a fan with high air expenditure and radial emissions. These types of sprayers are particularly useful for the protection of Italian type orchards, where the tops of the tree crowns merge over the inter-rows (Table 14).

In orchards with a sufficiently large distance between the tops of the tree crowns in

the inter-rows, two-fan sprayers with vertical, high-reaching air outlets are a good alternative (Table 14). In addition to the high air expenditure generated by the two fans, they ensure an even vertical distribution of the usable liquid and thus better precision of application of plant protection products in trees with low liquid losses.

3. Sprayers

In the protection of hazel orchards, typical, pressure swirl sprayers are mainly used, which produce a stream of fine drops in the form of a hollow cone and a spray angle of 80o, which work most effectively in the range of 5–15 bar. During windy weather (above 2.5 m/s) small drops are easily carried away, making it difficult to carry out an effective treatment. Therefore, in such conditions, coarse-droplet ejector, swirl or flat-fan sprayers with a spray angle of 80° or 90° should be used. In the absence of ejector sprayers, the size of the droplets may be increased using swirl sprayers with a higher discharge and the lowest liquid pressure possible. The output of narrow-angle swirl and flat-fan sprayers meeting the ISO standard, depending on the size and liquid pressure, is shown in Table 13.

Table 13. Nominal liquid flow rates [L/min] for whirl and flat fan sprayers with a spray angle of 80o or 90o, meeting the ISO standard, as a function of liquid pressure [bar]

Rozmiar ISO	L/min															
	bar															
	5	6	7	8	9	10	11	12	13	14	15	16	17	18	18	20
01	0,51	0,55	0,60	0,64	0,68	0,72	0,75	0,78	0,82	0,85	0,88	0,91	0,93	0,96	0,99	1,01
015	0,76	0,83	0,90	0,96	1,02	1,07	1,13	1,18	1,22	1,27	1,31	1,36	1,40	1,44	1,48	1,52
02	1,01	1,11	1,19	1,27	1,35	1,42	1,49	1,56	1,62	1,68	1,74	1,80	1,86	1,91	1,96	2,01
025	1,28	1,40	1,52	1,62	1,71	1,81	1,90	1,98	2,06	2,14	2,22	2,29	2,36	2,43	2,49	2,56
03	1,52	1,64	1,79	1,91	2,03	2,14	2,24	2,34	2,44	2,53	2,62	2,70	2,79	2,87	2,94	3,02
04	2,02	2,21	2,37	2,53	2,68	2,83	2,97	3,10	3,23	3,35	3,47	3,58	3,69	3,80	3,90	4,00
05	2,50	2,74	2,96	3,17	3,36	3,54	3,71	3,88	4,04	4,19	4,34	4,48	4,62	4,75	4,88	5,01

4. Efficiency of the fan

In order to penetrate spatial crops, the air in the plant rows should be replaced by air generated by the fan(s). Excessive sprayer speed does not ensure adequate penetration, while too low a speed, especially in young orchards, contributes to losses caused by blowing and drift of the spray liquid. This means that the efficiency of the fan should be appropriately related to the operating speed and size of the plants, being large enough to ensure even application, but also low enough to minimise liquid losses caused by blowing. The fan performance is adjusted by changing the gear ratio or changing the angle of the rotor blades, or, as a last resort, by changing the engine speed in the tractor. For the latter method, the

adjustment range is small, as it involves a simultaneous reduction in the efficiency of the sprayer pump, which increases pressure pulsation and worsens the effect of mixing liquids in the tank.

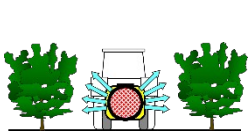
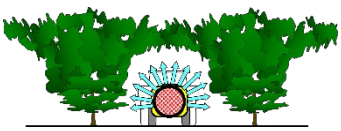
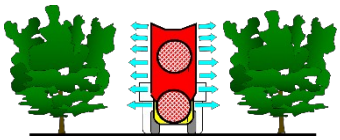
5. Operating speed

When protecting hazel orchards, the spraying speed should not exceed the range of 4.0–8.0 km/h. Treatments in windy conditions and in the case of particular density of spatially elaborate plants should be performed using the lower speed range (4.0-5.0 km/h). In early spring, when there is little foliage on trees, the operating speed may be increased to 8.0 km/h. Too low operating speed, for a sprayer equipped with a high-performance fan(s), worsens the conditions for applying droplets and causes liquid losses as a result of its 'blowing' through rows of trees or shrubs.

6. Dose of spray liquid

The dose of liquid when spraying hazel cannot be too low, as it does not guarantee a sufficiently even distribution of plant protection products in the trees. Too high a dose causes liquid dripping, which reduces the weight of the active substance of the product and, as a consequence, may lead to a deterioration in the effectiveness of the treatment. The range of application of liquid doses depends mainly on the type of sprayer and the size of the trees. Lower doses are recommended for juvenile orchards when the trees do not reach the target size. The recommended liquid dose ranges for typical situations are shown in Table 14.

Table 14. Liquid doses applied in hazel orchards using different types of sprayers

Sprayer	Standard		Double-fan
	Young orchard 	Italian type orchard 	Adult orchard 
Dose of liquid [L/ha]	**500÷700**	**700÷1 000**	**700÷1 000**

7. Weed control technique

Herbicides are applied using flat-jet sprayers that produce a spray of droplets in the shape of a flat fan. In the standard version, they produce small and medium-sized drops, which allow for the correct effectiveness of treatments, but tend to drift. Their use should be limited only to the control of monocotyledonous weeds in optimal or favourable weather conditions (Table 12) and to herbicide beams fitted with sheaths. The safest way to combat weeds is with coarse-droplet sprayers, usually of the ejector type. If there is a high

proportion of monocot weeds, the use of medium-droplet sprayers is also acceptable.

In the group of ejector sprayers, two-jet sprayers deserve special attention, where one jet is tilted forwards and the other backwards, typically creating a +30°/-30° stream arrangement. This solution is used to improve the application of herbicides on weeds, both in the early and late stages of their development.

Foliar herbicides are applied in liquid doses of 150-250 L/ha, and soil-applied herbicides in doses of 250-300 L/ha, always using coarse-drop sprayers.

Field sprayers are used to weed the site before establishing an orchard, enabling spraying of grown weeds over the entire surface of the field. In such cases, flat-fan sprayers with symmetrical streams and a wide spray angle (110–120°) should be used, enabling even coverage of the sprayed surface. In existing orchards, weeds are controlled using herbicide booms usually equipped with 3–4 sprayers, of which the outermost one, reaching under the tree crowns, is an asymmetric sprayer, and the remaining ones are standard sprayers with a spray angle of 110–120°. Weeds occurring in spots can be controlled using a knapsack sprayer with a lance fitted with a shield.

The operating pressure range for standard and ejector compact flat-jet sprayers is 1.5-5 bar, and for ejector sprayers, the so-called long one, 3-8 bar. The output of wide-angle flat fan sprayers and asymmetric sprayers meeting the ISO standard, depending on the size and liquid pressure, is presented in Table 15.

8. Sprayer calibration

Calibration of the sprayer is the responsibility of every professional user of plant protection products. This obligation follows from the Plant Protection Products Act (consolidated text, Journal of Laws 2024, item 630). Calibration involves determining, selecting and regulating its operating parameters in a way that ensures precise implementation of the intended liquid dose with the lowest possible losses. In the course of calibration, the following parameters shall be selected:

- sprayers: type, size, number on the sprayer's operating width,
- pressure of liquid,
- sprayer discharge,
- operating speed,
- airflow efficiency.

Table 16 shows the calibration procedure for orchard sprayers. When calibrating, use the appropriate sprayer flow tables (13 and 15).

Table 15. Nominal liquid flow rates [L/min] for ISO sprayers of sizes 01 to 06 as a function of liquid pressure [bar] and liquid dose [L/ha] at different working speeds [km/h]

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

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

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

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

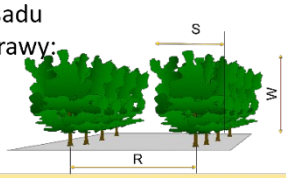
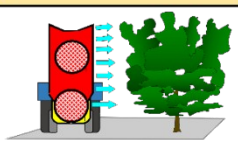
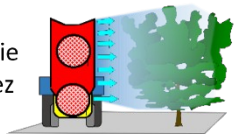
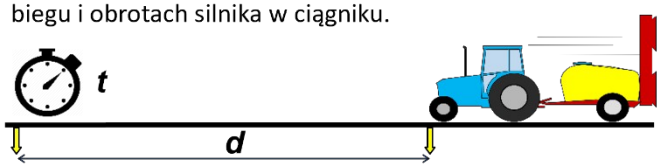
02		L/ha						
		km/h						
bar	L/min	4,0	5,0	6,0	7,0	8,0	10,0	12,0
1,5	0,57	170	137	113	97	85	68	57
2,0	0,65	196	156	131	112	98	78	65
2,5	0,73	219	175	146	125	110	88	73
3,0	0,80	240	192	160	137	120	96	80
4,0	0,92	277	221	185	158	139	111	92
5,0	1,03	310	247	207	177	155	124	103
6,0	1,11	333	266	222	190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

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

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

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

Table 16. Calibration of the orchard sprayer

KALIBRACJA OPRYSKIWACZA SADOWNICZEGO	PRZYKŁAD
1 Oblicz optymalną dawkę cieczy dla swojego sadu na podstawie podstawowych parametrów uprawy: **W** - wysokość koron drzew **S** - szerokość koron drzew **R** - rozstawa rzędów 	*W = 4,0 m* *S = 3,0 m* *R = 6,0 m*
Dawka cieczy [l/ha] = $\frac{\text{Wysokość [m] x Szerokość [m]}}{\text{Rozstawa rzędów [m]}}$ *x 400*	$\frac{4,0 \times 3,0}{6,0} \times 400 = 800$ *l/ha*
2 Określi liczbę pracujących rozpylaczy tak, aby, zakres ich działania nie wykraczał poza wielkość koron drzew. 	*Wyłączone rozpylacze* *n = 2 x 8 szt*
3 Obserwując zakres działania rozpylaczy dobierz obroty wentylatora tak, aby podczas jazdy w sadzie do minimum ograniczyć przewiewanie cieczy przez drzewa. 	*Obroty silnika: 1500 o/m* *Bieg w ciągnika : II* *Przekładnia went.: II*
4 Oblicz prędkość roboczą opryskiwacza na podstawie pomiaru czasu przejazdu na odcinku drogi o znanej długości, na ustalonych jak wyżej biegu i obrotach silnika w ciągniku. 	*d = 100 m* *t = 72 sek*
Prędkość [km/h] = $\frac{\text{Długość odcinka pomiarowego [m]}}{\text{Czas przejazdu [sek]}}$ *x 3,6*	$\frac{100}{72} \times 3,6 = 5,0$ *km/h*

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

Prędkość dla odcinka 100 m można odczytać także z tabeli

5 Oblicz jednostkowy wydatek rozpylaczy potrzebnych do realizacji wyznaczonej dawki cieczy w swoim sadzie przy obliczonej jak wyżej prędkości roboczej.	*Dawka cieczy = 800 l/ha* *Rozstaw rzędów = 6,0 m* *Liczba rozpylaczy = 16* *Prędkość = 5,0 km/h*
Wydatek [l/min] = $\frac{\text{Dawka [l/ha] x Rozstawa rzędów [m] x Prędkość [km/h]}}{\text{600 x Liczba rozpylaczy}}$	$\frac{800 \times 6,0 \times 5,0}{600 \times 16} = 2,50$ *l/min*
6 Z tabeli wydatków nominalnych wybierz rozpylacze i ciśnienie cieczy, dla których wydatek jednostkowy jest najbliższy obliczonemu jak powyżej.	*Rozpylacze ISO:* *03 (niebieski) - 14,0 bar* *04 (czerwony) - 8,0 bar*
7 Zamontuj wybrane rozpylacze, uruchom opryskiwacz i ustaw nominalne ciśnienie odczytane w tabeli wydatków. Przy użyciu wyskalowanego naczynia zmierz w ciągu 1 minuty wydatek kilku rozpylaczy na każdej sekcji i w razie niezgodności wyniku z wydatkiem wymaganym skoryguj ciśnienie i powtórz pomiar. 	*Rzeczywiste, skorygowane wartości ciśnienia po pomiarze wydatku rozpylaczy:* *03 - 15,0 bar* *04 - 8,5 bar*
8 Zapisz wszystkie uzyskane wyniki kalibracji w tabeli.	

IX. HEALTH AND HYGIENE RULES

Dr Grzegorz Gorzała

During harvest and the preparation of crops produced under integrated plant production for sale, the producer ensures that the following health and hygiene rules are followed.

1. Personal hygiene of workers

Persons involved in the harvest and preparation of produce for sale should:

- not be infected with or suffer from food-borne diseases;
- maintain personal cleanliness, obey the rules of hygiene, and in particular often wash hands during work;
- wear clean clothing and, where necessary, protective clothing;
- treat injuries and abrasions with a waterproof dressing.

The fruit producer ensures that the workers that participate in the harvesting and preparation of fruit for sale:

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

2. Hygiene requirements for agricultural products

During the preparation for sale, the plant producer shall take measures as necessary to ensure:

- clean or consumption-class water is used to wash the crops as necessary;
- the protection of crops during and after harvesting against physical, chemical, and biological pollution.

3. Hygiene requirements for packaging, means of transport and places of storage of agricultural products

During the preparation of agricultural products for sale, the producer in the integrated plant production system shall take measures, as appropriate, to ensure that:

- cleanliness of rooms (and equipment), means of transport and packaging is maintained;
- farmed and domestic animals have no access to the rooms, vehicles or packaging;
- harmful organisms (pests and organisms hazardous to humans), that may cause contamination or threat to human health, e.g. Mycotoxins, are eliminated;
- hazardous waste is not stored together with agricultural produce prepared for sale.

X. RULES FOR EEPING RECORDS IN INTEGRATED PLANT PRODUCTION

Cultivation of plants in the integrated plant production system is inherently linked to the maintenance or possession of various types of documentation by the agricultural producer. An obligatory item of this documentation is the IP notebook.
A model notebook is included in the annex to the Regulation of the Minister for Agriculture and Rural Development of 24 June 2013 on documenting activities related to integrated plant production (consolidated text, Journal of Laws 2023, item 2501). The record-keeping rules will change on 1 January 2026 as a result of the application of Commission Implementing Regulation (EU) 2023/564.

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

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

The certification process begins with the producer completing and submitting to the certification body, within the statutory deadline, an application for participation in integrated plant production. A model application may be obtained from the certification body or downloaded from its website.

The following information must be included in the application form:

- the name, surname, 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.

The application must also include the date and signature of the applicant. The

application 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.

The application must also be accompanied by a copy of the certificate of completion of training in integrated plant production or a copy of the certificate, or copies of other documents confirming the qualifications held.

During the cultivation process, the agricultural producer is obliged to keep ongoing documentation of activities related to integrated plant production in the IP notebook. If you are applying for a certificate for more than one plant species, you must keep IP notebooks individually for each crop.

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

Cover — state the plant species and the year of cultivation as well as the number in the plant producers' register on the cover. Next, complete own information.

Inventory of fields (...) in the integrated plant production system - record 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 given elements. Use the same markings on the farm plan as in the field list.

General information, sprayers, operators - record the year in which production according to the principles of Integrated Plant Production was started. Next, fill in the tables. Fill in the bullet points with appropriate entries and confirm information by ticking the relevant boxes (□). Fill in the 'Sprayers' table with the required data and the confirm information by ticking the relevant boxes (□). List all sprayer operators carrying out plant protection treatments in the 'Sprayer operator(s)' table. It is absolutely necessary to confirm that the training in the use of plant protection products is up to date and enter the date of its completion (or gaining other qualifications). List all devices and persons performing treatments, including those performed by a service provider, in the 'Sprayers' and 'Sprayer operator(s)' tables.

Purchased plant protection products - list 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 sticky boards, pheromone traps - in the table, record the used colour sticky boards, pheromone traps, etc. and indicate pests which these tools were intended to monitor.

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

Seed material (...) - complete the table by entering information on the plants purchased – variety, level of certification, quantity and proof of purchase (invoice, plant passport or official label attached to the plant passport, supplier's nursery document or accompanying nursery document).

Sowing/planting - record the number of plants used in individual fields. Record the dates of the activities carried out. Confirm information on soil testing/assessment for existing pests that exclude the field from IP cultivation by ticking the relevant boxes (□).

Soil/substrate and plant analysis and fertilisation/fertigation - soil analysis is a fundamental activity to determine the fertiliser needs of plants. A producer growing crops in the IP system must perform such analyses and record them in a notebook. Enter the field code, the type or scope of testing and the number and date of the report in the 'Soil and plant analysis' table. Record all organic fertilisers applied in the 'Organic fertilisation (...)' table. In the 'Type of fertiliser (...)' column provide the type or composition of the mixture when using green fertilisers. In the next table, 'Mineral soil fertilisation and liming,' record the date, type and dose of fertilisation and liming used and the place of its application. The table 'Observations of physiological disorders and foliar fertilisation' is a record of observations of plant nutritional deficiencies and constitutes a register of fertilisers used. The IP producer must regularly inspect the crops for the occurrence of physiological diseases and record this fact each time. Foliar fertilisation should be correlated with the conducted observations of physiological disorders.
Inspection observations and record of plant protection treatments - the plant protection tables are the basic element of the IP notebook. The first table 'Observations of weather conditions and plant health' is a detailed record of observations, in which we record the data indicated in the heading. In this table, the need for chemical treatment is also indicated. The next two tables are registers of plant protection treatments (agrotechnical, biological and chemical) and are closely correlated with the observation table. When carrying out this type of procedure, it is mandatory to record the name of the plant protection product or the biological or agrotechnical method applied, as well as the date and place of treatment. 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. the use of desiccants. Filling the mandatory IP notebook in the integrated plant production system fulfils the requirement to keep the above-mentioned documentation for certified crops. The rules for keeping records of plant protection treatments will change on 1 January 2026 as a result of the application of the provisions of Commission Implementing Regulation (EU) 2023/564.
Harvest - in this table, record the volume of crop taken from each field.
Hygiene and sanitation requirements - record whether people in direct contact with food have access to clean toilets and hand-washing facilities, cleaning products, and paper towels or hand dryers. Also the manner of observing the hygiene and health requirements for IP methodologies should be described.
Other mandatory requirements for the protection of plants against pests according to the requirements of the integrated production methodology - a page in the notebook containing space for IP producer comments concerning requirements for plant protection against pests set out in the integrated plant production methodologies.
Information relating to cleaning of machines, equipment, and hardware used in production according to the requirements of the integrated production methodology - a page in the notebook containing space for IP manufacturer information relating to cleaning of machinery, equipment, and hardware used in production which is required in the integrated production methodology.

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

It is possible for an agricultural producer to obtain an IP certificate by applying to a certification body. Forms for the relevant applications are available from the certification bodies. Along with the completed application for a certificate certifying the use of integrated plant production, the plant producer shall provide the certifying entity with a statement that the cultivation 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.

XI. LIST OF MANDATORY ACTIVITIES AND TREATMENTS IN THE INTEGRATED COMMON HAZEL PRODUCTION SYSTEM

Basic requirements (100% compliance, i.e. 15 points)			
No.	**Control points**	**YES/NO**	**Comment**
1.	Carrying out of soil analysis in terms of pH, organic matter content and available phosphorus, potassium and magnesium - on light soils at least once every 3 years, and on heavier soils - at least once every 4 years (see chapter II.1.1).	□□	
2.	Application of deacidification agents, mineral/organic fertilisers or soil improvement agents containing nitrogen, phosphorus, potassium and/or magnesium, based on the results of soil analysis and visual assessment of plant condition (see chapter II.1.2-1.4, 2).	□□	
3.	The use of mineral fertilisers containing the necessary micronutrients on the basis of a visual assessment of the plants (see Chapter II.5.5).	□□	
4.	Regular use of herbicides only on part of the plantation – optional under forest canopies or in inter-rows. The width of the herbicide strips should not exceed 3 m (see Chapter III.2).	□□	
5.	Do not use soil herbicides1 on plantations older than three years (see Chapter III.2). 1If such plant protection products are permitted for sale and use in this crop	□□	
6.	Use of plant protection products from the current list of recommended products for IP (see Chapter V.4; VI. 4).	□□	

7.	Alternating use of preparations with different mechanisms of action (rotation) in order to prevent the development of pesticide resistance (see Chapter III. 2; VI. 4).	□□	
8.	Recording total daily precipitation throughout the period of use of plant protection products (see Chapter V. 5).	□□	
9.	Monitoring for the occurrence of fungal and bacterial diseases and removing infected organs if they occur (see Chapter V. 3).	□□	
10.	Conducting systematic inspection of the occurrence of symptoms of diseases from the beginning of vegetation to the fall of leaves (see Chapter V. 2).	□□	
11.	Decision-making on the need to perform the treatment based on the real (actual) presence of the source of infection on the plantation/crop location (see Chapter V. 2)	□□	
12.	Regular monitoring of pests (hop spider mite, hazel spider mite, filbert bud mite, hazel aphid, rose tortrix, European fruit lecanium, nut weevil) from early spring if they occur on the plantation (see Chapter VI.2).	□□	
13.	Including non-chemical preparations in the control of spider mites, aphids, and coccids (at least one treatment should be performed with such a preparation) (see Chapter VI.3).	□□	
14.	Creating suitable conditions for the presence of birds of prey, i.e. setting perches numbering at least 1 per 5 ha, and in the case of larger plantations – several pieces (see Chapter VI. 5).	□□	
15.	Placement of 'houses' for mason bees or mounds for bumblebees, at least 1 per 5 ha, and in the case of larger plantations – several pieces (see Chapter VI. 5).	□□	

Nota bene

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

XII. CONTROL LIST FOR FRUIT CROPS

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

No.	Control points	YES/NO	Comment
1.	Does the producer produce and protect the crops according to detailed methodologies approved by the Main Inspector?	□/□	
2.	Does the producer have up-to-date IP training confirmed by a certificate, subject to Articles 64(4), (5), (7) and (8) of the Plant Protection Products Act?	□/□	
3.	Does the producer apply plant protection products exclusively from the list of IP-recommended products?	□/□	
4.	Are all required documents (e.g. methodologies, notebooks) present and kept on the farm?	□/□	
5.	Is the IP Notebook kept correctly and up-to-date?	□/□	
6.	Does the producer systematically 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 expired in accordance with the applicable legal regulations?	□/□	
8.	Is chemical protection of crops replaced by alternative methods wherever justified?	□/□	
9.	Is/was chemical protection carried out on the basis of hazard thresholds and pest signalling (where possible) as well as the results of the crop disease risk assessment?	□/□	
10.	Are procedures using plant protection products carried out exclusively by persons having an up-to-date, as of the date of such procedures, certificate on the completion of training in the scope of the application of plant protection products or advisory on plant protection products, or integrated plant production, or any other document confirming the right to apply plant protection products?	□/□	
11.	Are the applied plant protection products approved for use in the given cultivation - plant?	□/□	
12.	Is each use of plant protection products recorded in the IP notebook taking into account the reason, date and place of use, the area of the crops, the dosage of	□/□	

	the preparation and the amount of the spray liquid per unit 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 performing the treatments, if possible?	□/□	
15.	Does the producer limit the number of treatments and the amount of crop protection products used to an indispensable minimum?	□/□	
16.	Does the producer have measuring devices to precisely determine the quantity of the measured plant protection product?	□/□	
17.	Are the conditions for safe use of the products 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 distances from areas not used for agricultural purposes?	□/□	
19.	Are prevention and withdrawal periods observed?	□/□	
20.	Are the doses and maximum number of procedures during the growing season specified on the label of a plant protection product not exceeded?	□/□	
21.	Are the sprayers listed in the IP notebook in working order and have current technical inspections?	□/□	
22.	Does the producer carry out systematic calibration of the sprayer(s)?	□/□	
23.	Does the producer have a separate space for filling and cleaning the sprayers?	□/□	
24.	Does the handling of residues of the operating liquid comply with the indications on plant protection product labels?	□/□	
25.	Are crop protection products stored in a marked closed room in such a way as to prevent contamination of the environment?	□/□	
26.	Are all plant protection products stored exclusively in their original packaging?	□/□	

27.	Does the IP producer comply with hygiene and sanitary rules during plant production, in particular those specified in the methodologies?	□/□	
28.	Are appropriate conditions for the development and protection of beneficial organisms ensured?	□/□	
	Total points		

Additional requirements for plant producers (minimum 50% compliance i.e. 6 points)

No.	Control points	YES/NO	Comment
1.	Have the plant varieties grown been selected for integrated crop production?	□/□	
2.	Does the applied planting material have a certificate confirming its health status?	□/□	
3.	Is each quarter/field marked according to the entry in the IP notebook?	□/□	
4.	Are fertiliser application machines maintained in good working order?	□/□	
5.	Do fertiliser application machines allow for accurate dose determination?	□/□	
6.	Is each fertilisation application recorded including form, type, date of application, amount, place of application and surface area?	□/□	
7.	Does the producer protect empty plant protection product packaging against access by unauthorised persons?	□/□	
8.	Is the presence of predatory mites, *Chrysoperla*, ladybirds and other predators in the orchard recorded?	□/□	
9.	Does the producer have a properly equipped space for collecting waste and rejected crops?	□/□	
10.	Are there first-aid kits in the vicinity of workplaces (e.g. storage rooms, utility rooms, cold storage)?	□/□	

11.	Does the producer use consultancy services?	□/□	
	Total points		

Recommendations (min. implementation 20%, i.e. 2 points)			
No.	**Control points**	**YES/NO**	**Comment**
1.	Are soil maps drawn up for the farm?	□/□	
2.	Are non-organic fertilisers stored in a clean and dry room?	□/□	
3.	Has a chemical analysis of organic fertilisers for nutrient content been carried out?	□/□	
4.	Is there an irrigation system on the farm that ensures optimal water consumption?	□/□	
5.	Is the water used for irrigation laboratory-tested for the presence of microbiological and chemical contaminants?	□/□	
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 a spill or the scattering of plant protection products?	□/□	
8.	Does the producer restrict access to the keys and warehouse in which plant protection products are stored to persons who do not have the authority to use them?	□/□	
9.	Does the producer deepen their knowledge at Integrated Plant Production meetings, courses or conferences?	□/□	
10.	Does the producer provide conditions in the crop environment that are conducive to the survival of natural enemies of harmful organisms?	□/□	
	Total points		

XIII. GENERAL RULES FOR ISSUING CERTIFICATES IN INTEGRATED PLANT PRODUCTION

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

Integrated production training is generally available, and those who have acquired the appropriate knowledge through education (confirmed by a post-primary school or higher education) are exempt from the obligation to complete basic training.

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

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

- completion of an IP training;
- running production in compliance with the methodologies approved by the Main Inspector of Plant Health and Seed Inspection;
- fertilisation;
- documentation;
- compliance with hygiene and health rules;
- collection of samples and inspection of the highest tolerable plant protection product residues as well as of nitrates, nitrites and heavy metal levels in plants and plant products.

Tests for maximum permissible residues of plant protection products and levels of nitrates, nitrites and heavy metals in plants are carried out on plants or plant products from no less than 20% of plant producers entered in the register of producers kept by the certifying entity, with priority being given to tests carried out on plant producers suspected of failing to comply with the requirements of integrated plant production.

The tests are carried out in laboratories accredited to the relevant extent pursuant to the provisions of the Act on the Conformity Assessment System of 30 August 2002 or the provisions of Regulation No 765/2008.

Producers of plant products intended for human consumption should know the values of the maximum permissible residue levels of pesticides (Regulation (EC) No 396/2005 of the European Parliament and of the Council of 23 February 2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin. They should seek to reduce and minimise residues by extending the period between the use of pesticides and harvest.

The currently applicable maximum pesticide residue levels in the European Community are published at the following internet address: https://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/start/screen/mrls.

A certificate issued at the request of the grower attests that integrated plant production principles are followed.

An integrated plant production certificate is issued if the grower meets the following requirements:

1) has completed an integrated production plant training and holds a corresponding training certificate, subject to Article 64(4),(5),(7) and (8) of the Act on Plant Protection Products;
2) produces and protects plants in line with the detailed methodologies approved by the Main Inspector available on the website administered by the Main Inspectorate for Plant Health and Seed Inspection;
3) applies fertilisation based on the plant's actual nutrient demand

alimentary, determined in particular on the basis of soil or plant analyses;

4) documents the correct conduct of activities related to integrated plant production;
5) follows hygienic and sanitary rules in plant production, particularly those defined in methodologies;
6) 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.
7) adheres to requirements concerning plant protection against harmful organisms, particularly those specified in methodologies, during plant production.

The certificate which confirms the use of integrated plants production is issued for a period necessary for the sale of plants, but no longer than for 12 months.

A plant producer who has received a certificate certifying the use of integrated plant production may use the Integrated Plant Production Mark to label the plants for which this certificate was issued. The sample mark is made available by the Main Inspector on the website managed by the Main Inspectorate of Plant Health and Seed Inspection.

XIV. SUPPLEMENTARY REFERENCES

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