

The Plant Protection of the Potato



Morphology of the crop

The potato is a very common, worldwide-cultivated dicotyledonous plant. It originates from South-America (Peru, Bolivia). *The cultivated potato varieties (except the oldest ones, like Russet Burbank) are essentially artificial Solanum species-hybrids.*

The potato multiplies in a vegetative way, so this genetic combination is continuously stable.

Only a healthy plant with all healthy particulars can form healthy and sufficient yields.

The Tuber

The tuber of the potato is essentially a modified stem.

Its form is very varied. The chips varieties are usually round or round-oval. The special varieties for French fries are often long-oval, or extreme long. The special varieties for salad are usually long or extremely long too, often with a small bend. *The skin of the tuber may be red, pink, yellow, or brown netted (russet type). There is no connection between the colour of the skin and the quality of the variety.* The skin of the tubers can be flat (younger tubers), a little netted (older tubers), or russet-type netted.



The inner part of the tuber is divided to two parts: stem-end and sprout-end are expedient.

The stem end has got less eyes (location of the sprouts), lower dry matter content, but more vascular bundles. *Caused by the lower dry matter or starch content, the stem-end may have more infectious problems and disorders.*

Because the stem-end is relatively poor in sprouts, by the cutting of the seed potato (at some extraordinary big tuber developing varieties, like Russet Burbank it results higher yield and tubers) must take care of this situation. A part of the tuber without eyes will never develop sprouts.

The sprout-end of the tuber has more eyes, higher dry matter content. The eyes may be shallow (it is the best and the most common), or deep.

The external 1 cm of the potato tuber contains a ring around vascular tubes. When the vascular system is discoloured or gives slime or other exudate, the tuber is infected.



The NTN strain of the PVY causes a glassy ring spot between the vascular ring and the skin. This ring will later be necrotized.

Inhomogeneous vascular and starch content spreading, immoderate precipitation and mainly the ability of the cultivated variety for extraordinarily fast tuber growth can cause cracking on the surface of the tuber. These causes may result cavity too.



The lower dry matter content of the tuber or in a part of the tuber may cause physiological disorders (glassiness, cavity) and bacterial attack, and the tubers are not capable of long storing.

The average dry matter content, the colour of the flesh and skin, the possibility of several physiological disorders and pathogen infections depend on the cultivated variety.

The Sprout

The sprouts of the potato tuber are essentially extremely short young stems. The form and colour of the sprouts is characteristic of the cultivated variety.

There is no interaction between the colour of the sprout and the quality of the cultivated variety.

Stems develop from the sprouts. Sometimes, when the tuber is physiologically too old, the sprouts directly form small tubers.

Healthy sprouts of the potato are never elongated, they have a characteristic colour and form, a slight hair cover at some varieties. It must be without brown discoloration *or slime* exudation, so they might sign a fungal or bacterial infection.

The sprouts can be light-sprout. Storage-sprout and hair-sprout (Picture).

The best situation is when tubers have only light-sprouts. They are short, stubby, and have a representative colour and form. Healthy stems usually develop from such sprouts.

Storage-sprouts are long, etiolated, sometimes with some purple-red colouration. Healthy may develop stems from these sprouts, but the base of these stems will be more susceptible to bacterial or fungal attack than to light – sprout-grown stem.

Hair-sprout is a symptom of some tuber disease, first in all the potato stollbur infection. Hair-sprouts are extraordinarily thin, long, without any colour. Tubers, which develop hair-sprouts, never give any yield, usually die before their surfacing.

The Roots

Potato, like other dicotyledonous plants, has a main-root system containing some main roots and a lot of lateral roots. *Roots can only develop from sprouts and stems.*

(Picture)

The potato tuber or the stolons can never develop roots alone. The initiation of the young roots is well visible at the base of light sprouts.

Healthy potato roots are white or have a little sandy colour. Dry roots, when the plant is healthy, are never covered by the soil.

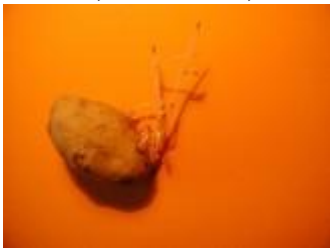
Brown, darker coloration on the roots is a sign of fungal diseases (*Rhizoctonia solani*, *Fusarium oxysporum*,). Violet-purple discoloration is a good marker of *Colletotrichum* attack. When dry roots are covered by the soil, the roots may be infected by bacteria (*Erwinia spp.*, *Ralstonia solanacearum*,).

The surface of the roots is (except the root-hairs) is flat. Small, round outgrows sign cyst nematodes, bigger amorphous knots mark the damaging of the root-knot nematodes.

Destruction of roots is signalled on the foliage. Partial or total wilt of potato foliage is often caused by the infection and damaging of the root system.

The Stolons

Stolons, like tubers, are modified stems. They can only develop from stems.



Other stolons or tuber or stems can only develop from the stolons.

The colour of healthy stolons is white, without outgrows. Brown discoloration (Picture) marks the infection of some fungus (*Rhizoctonia*, *Fusarium*, *Colletotrichum*). The *Colletotrichum atramentarium* fungus often causes violet-purple discoloration on the stolons.

When the surface of stolons has very small white, yellow, or brown half-balls, it is the best detectable sign of the presence of potato cyst nematodes.

Tubers or stems can develop at the end of the stolons, when the stolon reaches the soil surface. The number and length of stolons depend on the cultivated variety and on the soil, in part.

Some varieties first of all in a sandy soil, develop extremely long stolons.

Stolons usually have no branches, but some older varieties have some tendency for this adverse characteristic. The branching of the stolons results a chain-development of the tubers. The ability for chain-developing depends unanimously on the cultivated potato variety.

The Stem

The stems of the potato plant develop from the sprouts of the tuber, or from the end of the stolons. Roots, stolons and rarely other stems can develop from the stems under the soil surface. Above the soil surface, the stem develops leaves, by branching other stems and flowers.

Under the soil surface, the stem has a white colour, rarely with antocyanotic purple discoloration. Brown discoloration on the stems signs fungal (*Rhizoctonia*, *Fusarium*) attack. At the soil surface, black discoloration marks a bacterial infection by *Erwinia* species. This name is the black leg.

When the stem at the base, over the soil surface has a white covering under extremely wet conditions, it is a rare symptom of infection by *Rhizoctonia solani*.

The healthy stem over the soil surface has a green colour, some varieties have an antocyanotic purple coloration. *The length of stems mainly depends on the cultivated variety and more or less on nutrition. More nitrogen in the nutrition usually results longer stems and greater foliage.*

The stem system can be lying or standing. Varieties with a lying stem system cover the soil surface faster than the others. This is good from the point of view of weed control, but bad from the point of view of the spraying ability against pests and diseases. The stem system depends on the cultivated potato variety, but higher nitrogen nutrition might result stronger lying character.

When the sprouts at the base of the leaves develop green onion-like small tubers (they are the stem-tubers), the potato plant is severely infected by *Rhizoctonia Solani*, or potato stollbur phytoplasma. By this symptom the foliage usually wilts.

The Leaves

The leaf system of the potato is varied. A lot of long-oval small leaflets are lying on the top and on the two sides of the leaf-stalk.

The colour of the leaves, the size of the leaflets, the presence of adhesions between the leaflets, the form of the top leaflet, the surface of the leaves depends all on the cultivated potato variety and these characters can help farmers recognize the potato variety.

Healthy potato leaves are green, sometimes with some yellow or purple coloration.

The yellowing of leaves is not always a sign of infections. It may be caused by virus infection, too much nitrogen, too much water in the soil, not enough air in the soil, in some varieties a serious cyst nematode attack, or variety character. (Picture)

Rhizoctonia and potato stollbur often occur on the leaves with a purple discoloration, but it is terribly hard to recognize on varieties with an antocyanotic purple-coloured foliage.

Leaves with a non-systematic usually yellow pattern mark infection by some virus. This mosaic, when the sun shines heavily, is not easy to recognize. Systematic partial yellowing is often a physiological problem or variety character, and never a virus infection symptom.

When the turgor is higher than the normal, the plants are often infected by viruses.

The situation of the leaflets depends on the variety and on ambient conditions. A small curling up of the leaflets may be caused by water losses, infection of *rhizoctonia*, *colletotrichum*, or potato stollbur. It usually appears together with wilt. Small curling up without wilt, with a normal turgor pressure is a normal character of some varieties .

Growth and development of the crop

The potato plant has a lifecycle relatively hard to determine in Europe, some parts are usually connected, while others (flowering, tuber formation) are independent from the others. There are some artificial interactions, like the sprout destruction, which may have a big effect on the lifecycle and finally to the yield.

Dormancy

The yield of the potato, the potato tubers spend the biggest part of their lives in the storage, first of all the earlier varieties. The ability of the tubers for storing depends on the dormancy of healthy tubers.

Only healthy, full ripe tubers have the potential for sufficient dormancy. Tubers infected by pathogens, unripe tubers, tubers which have been sprouted in the present vegetation period, crossbred tubers, tubers with too low dry matter content have a much shorter dormancy period than healthy tubers.

Too young and too old tubers are not capable of utilising their potential dormancy endurance. The dormancy period has two major parts: obligate dormancy and enforced dormancy.

Obligate dormancy

Potato tubers, when fully ripe, except for some extraordinarily rare situations, never develop sprouts in the present vegetation period.



This situation is caused by an obligate plant-hormone-regulated vegetative period.

In this stage, tubers cannot develop sprouts when ambient parameters are good for sprouting. The duration of this vegetative life period depends on cultivated variety, dry matter content, health condition and temperature.

The extra early and early varieties usually have a shorter obligate dormancy, the later varieties have a longer one. High temperatures cause shorter, lower ones cause longer dormancy, so the multiplication of the temperature and the time spent at this temperature usually result a constant value. This value is representative of the cultivated variety and sometimes published in the descriptive lists of varieties.

Higher starch or dry matter content usually results a little longer dormancy. Extraordinarily low dry matter content of tubers may result absolutely short dormancy, bacterial, or fungal infections, or tubers, which are unable to sprout.

Attack by bacterial or fungal pathogens may result in a similar effect. The presence of pathogens usually results in much higher respiration and faster usage of stored assimilates. Finally, the pathogen attack usually results a dead or unsprouting tuber.

Enforced dormancy

At the end of obligate dormancy under good external conditions for sprouting the potato tubers develop sprouts. The development of sprouts depends on external conditions.

Under cold, not too wet conditions, when the tubers still contain enough stored dry matter, the sprouts do not develop. Warm wet storage conditions are optimal for sprouting.

When the potato tuber has no more stored assimilates, it begins to develop sprouts, also under not so good external conditions. Under good storage conditions, the transition between obligate and enforced dormancy is not visible.

The duration of enforced dormancy does not depend on cultivated variety, but the average dry matter content has some effect on this. Under optimal storage conditions, the time, when this stage ends, depends on the time, when the potato tuber gets exhausted. It depends first of all on the external storage conditions.

Sprouting

The development of sprouts is the first part of vegetative growth of the potato plant.

This stage begins with the appearance of small closed sprouts on the eyes of the potato tuber and ends with its surfacing.

Sprouts may be light-sprout, storage-sprout and hair-sprout. A healthy stem develops from the first two. (Picture)

The potato tuber needs sufficient temperature (higher than 8 °C) for sprout development. When soil temperature is lower, the sprouting process stops.

The pauses in sprout development are disadvantageous. Growing sprouts have a thin fragile surface vulnerable to bacterial or fungal infection. In cool wet soils, the hazard of *Erwinia* attack (blackleg), *Rhizoctonia* or *Fusarium* attack is much higher than in dry warm soils.

Infected sprouts never develop stems, so yields are reduced. The infection may penetrate back to the tuber easily, it may cause missing hills. Missing hills caused by too early plantation may result a higher weed problem. At the holes in the foliage, caused by the missing hills, the soil surface is not covered by the crop and is open to weed attack.

The most advantageous is when the sprouting process is as fast as possible. For such optimal development, the potato plant needs warm soil and enough water. Nutrition in this stage is not so important, but too much nitrogen may cause fast growth with extraordinary loose plant tissues, which is vulnerable to attack by bacteria or fungi.

Vegetative growth

Vegetative growth begins with the surfacing of sprouts.

In this stage, the plant develops stems and leaves, and plant material covering the soil surface. The mass, the type and the speed of the development depends on the cultivated variety.

Some early varieties do not begin a new growth at the flowering or at the end of tuber formation, at the end of their vegetation period. In this situation, vegetative growth ends once and finally at the end of the vegetative life of the plant.

Some later varieties have the potential for continuous growth. They end their vegetative growth when external conditions are disadvantageous (drought), and resume vegetative growth when circumstances improve.

This second form may result much higher yield, with a hazard of a lot of malformations, disorders and inhomogeneous dry matter content in the tubers. It may result marketing problems and storage problems. The resumption of vegetative growth needs a lot of nutrient and assimilates; and the plant, when the soil is poor in nutrients, lays them up from the developed tubers.

Flowering

The flower is the only reproductive part of the potato plant. It has no importance in the cultivation of the potato, because this plant is propagated by vegetative way.

Some varieties never or rarely ever develop flowers, others develop usually big, well visible flowers.



The size of flowers, the colour and the situation of the flowers (protuberant or hanging) are good markers of the variety and help farmers recognize the varieties. The potato was first an ornamental plant in Europe!

The colour of potato flower may vary from white to dark violet. Green petals are absolutely rare, but signal infection by potato stollbur (not common, but rarely visible symptom).

Appearance of flowers is totally independent from tuber formation or other phenological stages.

When plantation in the field begins the flowering in spots, it may cause the potato cyst nematode attack in some varieties.

The flowers and later the berries are often damaged by the cotton bollworm (*Helicoverpa armigera*) caterpillars. This pest never attacks the tubers, because the caterpillars feed only on reproductive plant parts (buds, flowers, fruits, because this parts contains tocopherol (Vitamin E), and without this material the imagos would be sterile.

Stolon and tuber formation

Very early varieties begin the tuber formation a little after surfacing, late varieties sometimes after the flowering, in the second half of the vegetative period. Tuber formation is independent from other phenological stages and depends significantly on the cultivated potato variety.

Optimal tuber formation needs continuous and steady nutrient and water supply. Problems in this supply may cause malformations and disorders.

The branching of stolons (variety characteristic) results tuber formations in chains. The age and the internal content of this tubers will be terribly inhomogeneous.



Malformations, protuberances are usually caused by unsteady water supply. In heavy clay soils it is more often than in sand.

Glassiness refers to inhomogeneous dry matter presence in the tuber.



*It is essentially a special form of the second growth. The tuber develops on the sprout end, and exhausts the dry matter from the stem end. It is a variety characteristic too. A glassy stem end is a good gate to attack by *Fusarium* fungi. Fungal attacks result in stem-end rot*



Long dry vegetation may result hard vascular bundles in some late varieties. Discoloration in vascular bundles or in other parts of the flesh is a rare variety characteristic .

Tuber cracking is often caused by unsteady water supply, inhomogeneous dry matter content, or high nitrogen nutrition.



Cavity is substantially a special, internal form of tuber cracking. The causes are the same. Disposition of excessive growth may cause cavity. At the round tuber form, it may be a line or similar to a star.



Extreme draughts cause the internal rust spot. Smaller or bigger brown discolorations are dead parts of the tuber. Some varieties have a strong disposition to this problem. The tobacco rattle virus causes (fortunately very rarely) similar symptoms, but the spots are dry and black.

The internal grey spots are caused by hard manipulation.

They are starch-leavings which may be discoloured. Only varieties with high starch content have the disposition. Prevention is very easy: do not hit the potato tubers.

Tubers may be infected from the stem-end by pathogens, which damage the leaves. Viruses can go down along the stolons into the tubers, it is well visible at the tuber necrosis, caused by the Potato Virus Y NTN strain. It forms rings around the stem end and the eyes.

The number and size of the tubers depend on the variety applied, but there are some artificial techniques, which can change these determined characters.

Ripening

Ripening substantially means stable, physiologically the dormancy status of the potato tuber.

The potato tuber – until the stolons die – is in dynamic contact with other parts of the potato plant. When the circumstances are good for vegetative growth, the plant might begin to use stored assimilates from the tuber.

The ripened potato tuber has a skin determined by cultivated variety, dry matter content, which is characteristic to the variety and the stolon at the stem end is not living yet.

Ripe tubers often have a chapped skin. Older tubers' skin is more often chapped than younger ones, but it is a variety character.

Only fully ripe tubers are capable for storing. Incapable younger tubers have no sufficient dry matter content, their respiration is much higher than that of ripe ones, and have a higher disposition to storage infections.

Ripe tubers develop a hard resistant skin in the soil. But too long periods in the soil may cause fungal attacks at some varieties.

OTHERS

There are some, in practice, living methods that are artificial interventions in the life of the potato plant, but can alter tuber yields, sizes or health conditions substantially.

There are some practical methods of artificial intervention, which influence the lifecycle of the potato, but in the same time these interventions can affect favourably the yield, the size or the health condition of tubers.

Sprout control

Basically the yield depends on the number of healthy, productive stem.

Well developed seed tubers have more eyes and at the beginning of sprouting only few sprout at first time. The hormones, coming from the growing sprouts, prevent the differentiation and growth the other sprouts.

Seed handling

Demand for fresh potato is very high in the market. The potato tuber in cold soil stops its development. These tubers can be easily infected by pathogen. To avoid such unfavourable conditions, the seed tubers of the earliest potato varieties must be kept in a warm, light and disease-free storage. Development of light sprouts are followed by root initiations. During plantation you have to be very careful in order to protect these sprouts. Tubers have to be kept in small boxes in one layer, if it is possible. Very high temperature (higher, than 20 °C) may results in too fast growth and etiolated sprouts.

Vine killing

Vine killing can be solution of the following problems:

1. Some varieties develop giant stems and leaf masse, which can detain the harvest.
2. Viruses can infect the tubers, going down the stem.

For the first problem the mechanical or chemical destroying of the foliage is needed in case of such late-season varieties, which have a large foliage, or have a disposition to a continuous vegetative growth. The information about the vector gradation are published by the plant protection authority in each country.

After destroying stems, farmers have to wait 1 - 2 weeks. During this period, the ripening of tuber is completed as well as ripened skin can develop on the surface of tubers. If you do not wait enough after destroying, you will find a lot of injured, unripened tubers after harvesting, which can be more sensitive for pathogen infections in the storage.

Regarding the problem of virus infection, the timing of stem destroying is the most important factor. All of the potato viruses are transferred by vectors. Most of the vectors are aphids. During the production of seed potato the presence of aphids must be monitored on field. Before the number of aphids reaches its peak (outbreak), the foliage have to be destroyed. In this way, we can prevent the seed potato tubers from virus infection. The information about the vector gradation are published by the plant protection authority in each country. The seed quality law in each country specify some regulations and controls of the seed potato.

Pathology

The diseases of the potato plant caused by viruses, bacteria or fungi are varied, but the causal organisms are usually invisible. Only the symptoms are visible, but may often be confused with each other or with physiological disorders.

Diseases caused by viroids, viruses, or phytoplasmas

Viruses or viroids are absolutely invisible, infected plants will never become healthy again. There is no direct plant protection material against virus diseases.

1. Name of disease: Potato spindle tuber

Causal organism: Potato spindle tuber viroid (Acronym: PsTVd)

The viroid only has a nuclein acid centre without polypeptide cover. It is fortunately very rare, and a lot of strains of the viroid are mild, not severely virulent.

Host range: Potato, tomato and some other wild *Solanum* species, like *Solanum nigrum* and *Solanum dulcamara*.

Occurrence and importance: *The EU is free from this disease, but the Eastern European countries such as Belarus, Poland and Russia are infected. The importance of the disease depends on its quarantine status.* The potato spindle tuber viroid is on List I/A1 of the EU. After the accession of Poland, it will be changed to I/A2, but will never be deleted from the quarantine list.

Symptoms and mistakable diseases: Mild and temperate races and strains cause no visible symptoms on the potato plant, but the viroid is present in them. *Virulent strains screw the stem top clockwise. Leaflets are elongated, dark green, and sometimes antocyanotic. Lateral sprouts at the base of the leaves begin to develop, causing a small witches broom. The plants are generally shorter than uninfected plants.*

The tubers of infected plants are smaller than the usual. The acuteness of the symptoms rises during the years of multiplication.

The viroid may cause serious losses in the 3rd, 4th and later years of multiplication. The tuber symptoms are somewhat mistakable for the symptoms of tuber formation in several steps. In this disorder there are bigger, non-spindled tubers too, and their stem end is sometimes glassy. The viroid infection results identical small tuber size, the age of the tubers is not so diverse, as with this disorder.

The detection of the spindle tuber viroid is not a job of the farmers. The plant protection authority in each state must discover and detect this infection.

Disease cycle: The viroid overwinters in the seed potato or in the tomato semen. It spreads in the vegetation by mechanical transmission or insect transmission. The insects are only mechanical vectors, the viroid cannot live continuously in the insect, it is not persistent.

Control: *The only useful control method is the use of certified seed material.* Directly imported seed material is tested for spindle tuber viroid in quarantine laboratories, and other aborigine seed materials in the vegetation are supervised by the competent state authority (such as the BSA in Germany, the INRA in France).

There are some tolerant varieties, but there is insufficient information about them. The state variety controlling authorities do no trials measuring the tolerance or susceptibility, because the disease is not yet present in the EU.

2. Name of disease: Potato virus Y

Causal organism: Potato virus Y (Acronym: PVY)

The virus has more strains. The previously common O strain causes small black ink spots on the backside of potato leaves. The N strain causes smaller – bigger necroses in the veins of the leaf on the backside. The NTN strain with this vein necroses can cause some ring necroses around the stem end and the sprouts on the tuber. *It is presently the most dangerous and most common strain across Europe.*

Host range: All annual and perennial, cultivated and wild species of the genera *Solanum* are first of all the hosts of the virus. Most severe damages are done to potato, tobacco and pepper. Some other weeds from other plant families are hosts, but without any importance.

Occurrence and importance: *The potato virus y is spread across the world. It is very common, often occurs in potato fields and responsible in the bigger part for the decline of the potato during the propagation.*

It may cause during one year 70%+ decline in the potato yield, and can absolutely exterminate some extraordinarily susceptible varieties in the fields. Some older varieties, like Gülbaba, Ella, Hertha are so susceptible to the virus that their cultivation is impossible in the fields, which are rich in vector organisms. The potato virus Y is not a quarantine disease, but causes higher yield losses than some quarantine organisms.

Symptoms and mistakable diseases: *The virus caused symptoms depend on the present strain of the virus and the susceptibility of the cultivated variety.*

The previously common, today rare strain O causes symptoms on the leaves only. Resistant and tolerant varieties only have a mild mosaic pattern (yellow pattern on the leaves, which has no periodicity or system). *On susceptible varieties, the leaves have small black ink spots on their backside.* The decline of the leaves is rare, but yield loss may be severe.



The more important and dangerous strain N is usually responsible for the necrotic decline of the potato plants in the field . In tolerant varieties, the virus usually causes mosaic patterns only in the first year. Later the leaves have brown-black coloured, dead small veins on their backside (from this symptom comes the name Y).

The high amount of dead veins leads to the necrosis of the whole leaf. Necrosis starts on the base leaves, the upper leaves are sometimes yellow, often with mosaic.



Dead leaves turn down, the plant is similar to a palm tree .Varieties (first of all the older ones, which are resistant to the strain O) are, very often susceptible to the strain N. So it is a resistance braking strain.

The presently most common and most dangerous NTN strain causes identical symptoms on the leaves to the N strain. The NTN strain can break the resistance of the varieties, which are resistant to the other strains to the potato virus Y. This resistance breaking strain in the last few years were dominant and caused severe damages everywhere.

The NTN strain causes firstly glassy, later necrotic rings around the stem end and the sprouts on the potato tuber skin



These symptoms are often visible on the very susceptible varieties. The less susceptible and the tolerant varieties have no or extra small rings.

The potato virus Y usually occurs together with other mosaic viruses. The presence of these viruses (potato virus M, N, A, S,) usually results in much more severe symptoms.

Infected plants are often dwarf and will die very fast. This complex virus infection often looks like a hole in the plantation.

The potato virus Y infection is easily mistakable for older symptoms of the late blight (Phytophthora infestans). The virus causes small black spots (O strain) or small necrotized veins (N and NTN strains) on the backside of the leaves. The late blight never causes these symptoms. Dried leaves are common symptoms, so the green leaves adjacent to dead leaves must be observed for the identification. The late blight causes (first of all under wet conditions or in the early hours a small, not easily visible white border at the destroyed leaf area. The late blight often infects a part of the leaf, while other parts of the leaf remain healthy. The potato virus infection usually occurs on the whole leaf.

Disease cycle: The disease overwinters in the seed potato, and in the perennial *Solanaceae* plants. The spreading needs a hard entomogen vector effect. The vectors are aphids. Either the own aphids of the potato (*Aulachortum solani*,) or the other species (first of all the *Myzus persicae*) are vectors, the *Myzus persicae* is the most common and most effective.

The potato virus Y is a stylet borne virus, the transmission is not persistent. After the infection, the virus goes down to the tubers along the stem, but only the NTN strain causes visible symptoms on the tubers.

Control: *The usage of resistant varieties is the easiest and most effective way of control.* Some varieties, like Santé, Snow-flake, Lilla are absolutely resistant to all presently known strains of this virus.

The usage of the state certified seed potato is useful too, the seed material contains a virus content certified under a low enough level. This material may be infected later, during the vegetation, the damage depends of the used variety.

The destruction of the stems is a good control in the seed potato cultivation. It prevents the contamination of the tubers initiating from the infected leaves.

Insecticide seed potato dressing (Gaucho, Prestige) and insecticide spraying has no effect, because the virus is not persistent and can give away the virus during a minute, before it would be killed by the insecticide.

The control of perennial solanaceous weeds, like Solanum dulcamara, Licium halimifolium is a good method of control, first of all in seed potato cultivation.

3. Name of disease: Potato leaf roll

Causal organism: Potato leaf roll virus (Acronym: PLRV)

This virus rarely exterminates the plant like Virus Y, but causes hard yield losses and is responsible in part for the decline of potato.

Host range: *Potato and all crops and weeds from the family Solanaceae.*

Occurrence and importance: *This virus occurs everywhere within the EU and in other European and neighbouring states. The virus may cause serious yield losses, very small and few tubers, but exterminates the whole plant like Virus Y only rarely. Leaf roll is responsible along with other viruses for the decline of potato and the retiring of old potato varieties.*

Symptoms and mistakable diseases: *The potato leaf roll virus (known from its name) causes a very well visible leaf rolling up: the leaflets are curled up to form a small boat. Infected plants are dwarf, the leaves are very fragile, and the whole plant is light, etiolated, just like antocyanotic varieties (Symphonia, Dura). Some varieties have a hard yellowing reaction. Leaf rolling usually begins at the top of the plant. Cutting across the stems, there are some necroses in the external part, under the skin of the stem.*



*Leaf roll symptom has several causes: appearance of potato stollbur phytoplasma, root infection by *Fusarium spp.*, *Rhizoctonia solani* or *Colletotrichum atramentarium* often cause leaf roll, but always with a smaller-bigger wilt. This symptom occurs at a hard cyst- or root-knot nematode attack. Fragile leaves, leaf roll and lighter colour together ease detection, in presence of these 3 symptoms the potato leaf roll virus infection is absolutely sure*

Leaf roll virus may occur in the plant together with other viruses, so their symptoms may be mixed.

Disease cycle: *The potato leaf roll virus overwinters in infected seed potato tubers and in perennial solanaceous weeds. The overwintering form, the egg of the aphids is not infected. The virus is persistent but not propagation persistent; infected vectors keep their infection ability until the end of their lives. Infected, overwintered plants and stored tubers are infection sources; aphids, first of all green peach aphid (*Myzus persicae*) are vectors. The virus is persistent, so transmission needs longer time, but the vector keeps its ability upto the end of its life.*

Control: *The control of the potato leaf roll virus depends on variety, agri-technical and chemical base. Resistance against this virus is not complete, there are no absolutely resistant (immune) varieties, but there are a lot of registered varieties that have good resistance against the virus. The Santé, White Lady and other resistant varieties have very small virus infection rates year after year. Use of such varieties an inexpensive and very effective method. The use of state-certified seed material is a useful way too. These seed potatoes have a low pathogen infection guaranteed by the state.*

*In seed potato production, good isolation may be useful. Greater distance between seed potato and other solanaceous planted fields may slow down the spreading of virus infection. Taking care to perennial solanaceous weeds (*Lycium halomifolium*, *Solanum dulcamara*) is also advantageous.*

Chemical control against aphids is useful against this virus. Since the potato leaf roll virus is persistent, the transmission of the virus is particularly much slower than the effect time of insecticides. So these products can kill aphids during suction, before the start of virus transmission. Effective insecticide seed dressing materials and spraying products are listed in the table on aphids.

4. Name of disease: **Potato mosaic**

<u>Causal organism:</u>	Potato Virus A	(Acronym: PVA)
	Potato Virus X	(Acronym: PVX)
	Potato Virus M	(Acronym: PVM)
	Potato Virus S	(Acronym: PVS)

Host range: Firstly, in all *crops and weeds of the plant family Solanaceae, rarely other weeds or ornamental plants.*

Occurrence and importance: *These viruses are home in all countries of the world where potato is cultivated. They are often invisible, sometimes cause latent infection, but are present in the field and in the crops.*

Mosaic viruses very rarely cause serious yield losses alone. They usually occur together with Potato Virus Y. This complex infection results extraordinary yield losses, necrotized and rapidly dying plants. *Their importance lies in strengthening symptoms and damages of other more dangerous viruses, first of all Virus Y.*

Symptoms and mistakable diseases:

Potato mosaic viruses (known from their name) cause unsystematic yellow patterns (called the mosaic). Symptoms are more visible in cool temperatures; symptoms are latent or not well visible under hot weather conditions.



The mosaic sometimes occurs with a slight growth-depression or not serious leaf-curling.

The presence of mosaic viruses is often mistakable for early Potato Virus Y infection, first in all not too later the infection, or on a tolerant variety. Both of viruses may cause mosaic. There is no importance: which one is the causal virus, the potato is in

any case infected.

Disease cycle: *Mosaic viruses overwinter in seed potato, rarely in perennial weeds. The main infection source is the infected seed potato. All mosaic viruses are not persistent and spread with aphids very well. Some viruses are also capable of mechanical transmission.*

Control: *Genetic control against mosaic viruses is not yet useful. Only very few varieties, like the Hungarian Lilla, have resistance against one of the viruses, especially the Lilla is resistant against Virus S. There are no varieties resistant against all mosaic viruses.*

State-certified seed potato is a very good control method. Using the ELISA-test, infected units are checked and boycotted, so certified seed potato has state-guaranteed low infection rate.

Chemical control is not useful. Because of the not persistent character of these viruses, the insecticide treatment against the mosaic viruses is ineffective.

5. Name of disease: **Internal rust spot and leaf necrosis**

Causal organism: Tobacco rattle virus (Acronym: TRV)

Host range: *The virus may infect about 100 species, firstly, all tobacco, potato, tomato, other solanaceous plants.*

Occurrence and importance: *The tobacco rattle virus occurs in every country where potato or tobacco is cultivated, but is sporadic everywhere and never causes plagues or endemics.*

The importance of this virus is only local, where occurrence is above average due to the higher density of vectors.

Symptoms and mistakable diseases:



The tobacco rattle virus causes small, 1-20 mm great dark brown, very hard spots in the flesh of the tuber and fast drying of the leaves.

The necrosis of the leaves is local, not as widespread as the damage caused by Virus Y.

Leaf symptoms are easily mistakable for Virus Y symptoms, but there are no blacked veins on neighbouring leaves. Tuber symptoms are terribly similar to physiological rust spots, but spots caused by this virus caused are a lot darker. Fortunately, the tobacco rattle virus is very rare, physiological rust spot occurs more often, firstly in susceptible varieties.

Disease cycle: *The pathogen overwinters in infected potato tubers, in perennial plants and in the bodies of vector nematodes. They are the sources of infection. The vectors (*Trichodorus* and *Paratrichodorus* species) are fortunately rare. These free living, very small, invisible nematodes transfer the virus, which is propagation persistent.*

Control: *The tobacco rattle virus is so rare that usually no control is necessary. Genetic control is not useful; due to low virus importance, there is no breeding against this virus.*

Continuous cereal or other monocot crop production may decrease the density of nematodes in the soil and the percentage of virus-infected vectors in the population.

Virus-free seed potato is necessary. When the soil is severely infected with virus-carrying nematodes, nematicide treatment may be useful, but it is very expensive. See useful nematicides at nematode pests.

6. Name of disease: Potato stollbur

Causal organism: Potato stollbur phytoplasma

This disease causal organism is invisible, like the viruses and in several characters is similar to them, but its genetics and structure are different.

Host range: *Many solanaceous crops (potato, tomato, pepper, eggfruit), weeds, and other perennial weeds (Convolvulus arvensis, Trifolium spp.), which are important reservoirs of the pathogen.*

Occurrence and importance: *Potato stollbur is home in the eastern, central and southern parts of Europe. Turkey and Israel are infected too. The pathogen causes infections, rarely plagues in dry hot years, when vector effectiveness is much higher than in other years.*

In dry hot years, potato stollbur may cause very heavy yield losses up to 80 %, with the total destruction of whole potato fields. The remaining yield is caused by late infection, but these tubers are absolutely unmarketable.

Symptoms and mistakable diseases:



The pathogen causes a continuously developing wilt and drying on the foliage. The leaves are slightly curling up with a slight pink-violet coloration. The leaves are a little yellow, only the top of the plant with the curling leaves has a pink coloration. The potato stem system develops a „witch's broom“, at the base of the leaves the sprouts hatch. These new stems are at the base stubby, like an onion and usually pink coloured. The plant dries out later.



The tubers are rubbery, wrinkled

Infected tubers usually develop hair-sprouts.

The tuber symptoms are not mistakable, no other pathogens causes „gum-tubers“.

The foliar symptoms are very similar to black scurf (Rhizoctonia solani) symptoms.

All symptoms are common, but the stollbur indicates a little hard pink coloration. The presence of

wrinkled gum-tubers is the only character, which makes sure the presence of the stollbur infection.

Disease cycle: *The pathogen overwinters in infected tubers and in overwintering parts of the perennial weeds. The vectors are several cicadas, first of all the very common Hyalesthes obsoletus. The pathogen is not stylet-born, thus transmission needs long time and the incubation period is very long (60 to 80 days from infection to first symptoms), the occurrence of the symptoms is usually in the second half of vegetation.*

Control: *Potato stollbur is not an aim of potato breeding, so there are no resistant varieties. State-certified seed potato is free from this disease, the presence of gum-tubers is forbidden in seed potato.*

Insecticide treatment against the cicadas may be useful, but expensive in potato production. All insecticides, registered against the Colorado-beetle, are useful except for biological preparations (Novodor), specific feed-poisons (Regent, Bancol, Padan), and development regulators (Ekos, Match, Nomolt,).

Effective weed control is important because the cicada a migrant insect not as good as aphids. Continuous and effective control of the convolvulus can result the decreasing of this disease.

Diseases caused by bacteria

Plant pathological bacteria are as invisible as viruses. Some bacteria are on the quarantine list. All bacteria prefer wet conditions and their symptoms develop well in wet or irrigated territories. The symptoms caused by bacteria are varied, depend on the causal species, but each develops slime at some part of the plant.

7. Name of disease: Bacterial brown rot

Causal organism: *Ralstonia solanacearum*

This disease causing bacterium currently has quarantine status and is in spreading in Europe.

Host range: *The entire Solanaceae family, some Fabaceae plants, and many weeds too.*

Occurrence and importance: *The pathogen is present in the Eastern Mediterranean and the Black Sea, in Hungary and in some parts of Western Europe (the Netherlands). In hot years, the presence is usually in latent form, without visual symptoms. The importance is caused by the quarantine status, but in wet and warm years may cause hard yield losses (up to 60 %).*

Symptoms and mistakable diseases: *Bacterium attack results a sometimes partial wilt in the foliage, when some stems do not have symptoms. The tuber and the stem cut across have a light brown ring in the vascular bundles. The pressure onto the surface of the stem or the tuber results a brown-light brown slime exudate protuberance. This is a distinctive character. Some other diseases may cause wilt (*Rhizoctonia*, *Colletotrichum*, *Stollbur.*), but they never result brown slime under pressure.*

Disease cycle: *The pathogen overwinters in infected seed potato tubers, often in latent form, without visible symptoms. The infected soil may also be a source of infection because the pathogen survives in the soil for a long time. The spreading on the field is due to water, but this spreading is not important. The pathogen uses lenticels or injuries for the attack, but the infection is also effective without them.*

Control: *Genetic protection cannot provide resistant varieties for farmers. Some varieties, like Kondor, Impala and others, which have an extraordinarily low starch content, are very susceptible to the *Ralstonia* attack.*

The use of state-certified seed material is the best way of control. Certified seed potatoes are guaranteed by the state to be free from this pathogen.

In the presence of the disease, reduced irrigation, harvest as early as possible may reduce yield losses and the amount of infection material. In infected soils, further potato production is forbidden by the national plant protection authority.

8. Name of disease: Bacterial wilt

Causal organism: *Clavibacter michiganensis ssp. sepedonicus*

Host range: *Only the potato, very rarely the sugar beet in latent form*

Occurrence and importance: *The bacterium occurs in the northern part of Europe (north of the Kiel-Warsaw-Moscow line). The pathogen is cool-liking and prefers wet conditions.*

The disease has a quarantine status, which gives its importance. The bacterium may cause moderate yield losses, but never exterminates whole fields. *The bacterial wilt is the disease of the cold years or countries.*

Symptoms and mistakable diseases: *The wilt, caused by this bacterium is very easily mistaken for wilts caused by Stollbur, other bacteria or soil fungi. The wilt is often partial, that is only a part of the stem system has symptoms. Cutting across the tubers, there is a dark-brown ring in the vascular bundles, which gives a white-light yellow slime exudate under pressure. This is an important symptom. Fungal or stollbur infections never give slime exudates, other bacteria do not make a ring (*Erwinia*), or give a brown exudate (*Ralstonia*).*

The Ralstonia and the Clavibacter do not have common occurrence countries. Brown rot causing Ralstonia solanacearum is a warmth-liking southern pathogen, bacterial wilt occurs only in the north.

Disease cycle: *The bacterium overwinters in the overwintering potato tubers, in the seed potato, and free in the soil too. They are the sources of infection. The spreading of bacterium may be fast, the soil-contaminated tools and some insects (Colorado beetle, aphids) can carry the pathogen in a simply mechanical way.*

Control: *Potato breeding at present has no resistant varieties against this disease. Those varieties, which contain an extraordinarily low starch content, or have a very loose structure, are more susceptible than others.*

Chemical control is absolutely ineffective, there are no useful products against soil bacteria.

The use of state-certified seed potato is a good control method, these materials are free from the pathogen.

Because of its quarantine status, the potato production is forbidden by the state plant protection authority after the detection of the disease.

Avoiding the use of alien tools and carrying machines can prevent the import and the spreading of the pathogen effectively.

9. Name of disease: **Blackleg and wet rot**

Causal organism: *Erwinia spp.*

The bacteria (*E. carotovora ssp. Carotovora*, *E. carotovora ssp. Atroseptica* and the *E. chrysanthemi*) often occur in European soils. The biggest damages in the fields are done in wet years, like 1999, or in the bad storages. *These bacteria cause blackleg in the field, and wet rot in the storage.*

Host range: *These bacteria are polyphagous. In the field, first of all potato and rooted vegetables are attacked. In the storage, the same goods and other stored soft stem plants.*

Occurrence and importance: *Erwinia species often occur all over the world. They are absolutely common diseases in the western and northern parts of the EU, because they prefer the wet lands.*

E. chrysanthemi is a little rarer than others, because this species likes warmth more than other species. *Irrigated fields and fields cultivated without regular (min. 4-year) crop rotation are often homes to such damages.*

Fields around the great cities or other territories, where the changing crops are hosts (carrot, other rooted vegetables), are usually rich in the *Erwinia* infection.

Occurrence in storage depends on the stored potato and the storage conditions. When a water film occurs in stored potato tuber hills, the bacterial attack spreads extremely fast. Farmers must take care to the ventilation in order to never cause water on the surface of the tubers. The bacteria may destroy the whole stored potato amount during the winter under bad storage conditions. Only susceptible varieties sustain severe damages in fields under irrigated or rainy conditions.

Symptoms and mistakable diseases: *Firstly, in case of every Erwinia attack, it is extremely easy to recognize through the terrible smell. Erwinia species have a common character in their damaging on the field and in the storage too. Their enzymes destroy the pectin material in the plant tissue, so the infected tissues will later be slimy or liquid.*

These bacteria are never alone in nature. Other saprophagous bacteria usually over-infect *Erwinia*-infected tissues. Activity of these bacteria results a terrible smell and black coloration.



Bacteria attack the base of stems in the fields contaminated with wet soil. The infected stem base will black (Picture), the stem lays down, wilts and later dies. Potato varieties, which have large foliage and low starch content in their tubers are more susceptible (like Kondor).

In the storage, the infected potato tuber is wet on the outside, loses its own form and has a terrible smell. Cutting across the tuber, the texture is destroyed and usually black. Tubers with glassy parts and low starch content are more susceptible.

The bacterial attack on the tuber is not mistakable for other diseases in the practice. Early field attacks are sometimes mistakable for damage by black scurf to the base of the stems. In both cases, the bases are black. The Erwinia infected stem smells like the hell, the Rhizoctonia infected stem smells like the earth. The stem base attacked by bacteria is always wet slimy, the stem base attacked by black scurf is usually dry. Stored in a plastic bag, the stems attacked by bacteria will be liquid, Rhizoctonia attack will cause a white cover (white sock).

Disease cycle: *Erwinia species live in the soil and can live latent during the cultivation of a lot of crops. Generally, there are no fields absolutely free from Erwinia species.*

The bacteria can infect the tubers across injuries or opened lenticels.

These bacteria attack the crop only in good conditions. Infective sources may be the soil and the seed potato. Storages are only infected from the fields.

In the storage, the infection might develop more seriously than in the fields, but it needs well infected stored potato amounts and bad storing conditions and/or ventilation errors. Empty storages are unfit for development of *Erwinia* species. Storages may be freed easily by using some disinfectants.

Control: *The use of non-susceptible varieties is the easiest way to control damage by such bacteria. Some varieties, like Kondor, Cornado are very susceptible to Erwinia attack. There are no absolutely resistant varieties, but some well known varieties (Agria, Asterix) are absolutely non-susceptible. The resistance status is found in the descriptive list of varieties, published in each state by the variety control authorities.*

The use of state-certified seed potato is a good method. This material has maximum a very low infection by bacteria guaranteed by the state. It is good, but even excellent seed material may seriously be infected in the field by infected soil.

Crop rotation is very important, the potato must return to the field in every 4th year at the latest. When the field is seriously infected, or the rotation crops are preferred crops, like carrot, their spacing must be longer.

Be careful with irrigation, first of all on heavy clay soils. Open lenticels of the tuber skin result a higher infection. Too much water increases the damage.

Too much nitrogen or other nutrition problems may cause soft plant tissues, which may be infected more easily than healthy plants.

In the storage, ventilation must be provided for. The development of a water film on the surface of stored tubers may cause high damages. Only air temperatures much lower than tuber temperature are capable for ventilation.

The stored potato unit must be homogeneous. Too young, glassy, and injured tubers are infected more easily than others.

There is no effective plant protection material against Erwinia species. Do not look for spraying materials, they are totally ineffective in the field. Storages may also be cleaned easily from these bacteria by inexpensive disinfectants, but infected tubers cannot be decontaminated.

Diseases caused by fungi

Fungi often cause diseases, which are similar to other ones caused by viruses or other living creatures. Fungi are sometimes visible (late blight), but often not. They may pollute the air and the soil as effectively as viruses or bacteria.

10. Name of disease: Late blight

Causal organism: *Phytophthora infestans*

This lower fungus is home where potato and other Solanum-crops are cultivated. *This fungus is responsible for the Great Potato Famine in Ireland in the 1840s.*

Host range: *Phytophthora infestans* infects only potato and tomato, but may develop natural hybrids rarely, which may infect other plants (tobacco, ...) too.

Occurrence and importance: Late blight is one of the most important potato diseases; it occurs in every wet land and country of the world. *Within the EU, the western, northern and - in wet years - central states are attacked by this fungus. Because the fungus needs water for the propagation and the invasion into the plant tissue, the southern states are usually free from this pathogen.* When external conditions are good for the fungus, it finds enough water, in the southern states and may cause epidemic illnesses, but never in the warmest months. *Over 30 °C the fungus retires or dies.*

The late blight may destroy whole potato fields, so in states with wet weather conditions the protection against this fungus is absolutely necessary. It may defeat the cultivation of extraordinarily susceptible varieties, like Russet Burbank under wet weather conditions.

The importance of this fungus is greater than that of others, which are quarantine diseases!

Symptoms and mistakable diseases:



Late blight causes symptoms on the foliage and on the tubers too. *Infected leaves have a dark green-brown coloration, wilts and later will be dry.*



In the early morning or under very wet conditions the infected part of the leaf has a small, white border, which is the outbreak of spores from the leaf. The causal fungus is an obligate parasitic pathogen, spores do not develop on the dead surface.



Infected tubers only have a few external symptoms, the skin is brown and a little wrinkled. Cutting across the tubers, the flesh is brown, coloration begins under the skin. Coloration is sometimes discontinuous and never causes an internal ring in the tuber.

Late blight is often mistaken for Potato Virus Y. Drying caused by the virus does not have a dark green-brown colour. Do not check the

dried leaf, only the living parts. The virus causes small ink spots or smaller-bigger black coloration of the veins on the backside of the leaves.

The late blight never causes these symptoms, but develop white rings in wet conditions.

Early blight (Alternaria solani) may cause similar symptoms, but Alternaria occurs in dry and hot weather while Phytophthora prefers wet and cooler ambient conditions.

Early blight causes more brown spots on leaves and they have a specific concentric pattern.

The tuber syndromes of late blight are sometimes mistakable for symptoms of other pathogens. Fusarium infection results concentric wrinkles, often at the stem end and the tuber flesh is black with white mycelia outside the tuber. Late blight never develops mycelia there.

Phoma attack causes similar symptoms but white mycelia are in caves caused by the fungus.

Bacterial brown rot causes brown discoloration, but it forms a ring and late blight never causes rings.

Internal rust spot causes similar brown spots, but they spread everywhere in the flesh and do not initiate from the skin.

Disease cycle: *The fungus has two sexual types. When both of them are present, the pathogen can develop after the sexual multiplication of spores, which can survive the winter in the dead plant tissue.* In presence of only one sexual type, sexual multiplication is impossible. So the fungus overwinters in the infected potato tuber as mycelia. In the southern states where the winter is not hard, the infected plants can survive the winter (potato, tomato berries) and the southern wind can transfer the spores to the northern states. The sexual usually overwintering results much earlier plagues, and the second sexual form (A2) is present in all EU states.

The fungus cannot live without fluid water. The spores (sexual and asexual too) form small swarming spores, which need to their movement fluid water. The swarming spores are the infective form of the fungus. They can use the lenticels of the tuber, the respiration holes of the leaves for the invasion into the plant tissue, but they can actively press out the upper cellular wall of the potato leaves. The spores washed down by rain or irrigation infect the tuber, the mycelial infection along down the stem is impossible.

After the infection the fungus lives as an obligate parasitic organism between the cells. There is a small time period between the infection and the occurrence of the symptoms called the incubation time while the fungus is present but invisible. Some chemical materials can stop the invasion even at this stage.

Through sexual multiplication, the fungus can easily accumulate resistance genes against herbicides and virulence genes against the vertically resistant varieties. These complex races are presently the most common within the EU.

Control: *Genetic control using resistant varieties is not complete.* Vertical resistance (built in the varieties Raja or White Lady) results a total protection for a few years. The new races usually break this resistance form. Horizontal resistance results a much smaller infection, with a small yield loss, but this form has got a very good durability (like the variety Santé). Under very wet conditions this resistance must be helped by chemical spraying.

There are a lot of chemical materials that have effect against the late blight. Contact materials are very useful when the weather is not too wet, not optimal for the pathogen, the foliage is not closed yet and it is well treatable. Copper and dithiocarbamate active ingredients are useful in this period, but there are other ingredients too. *The adhesiveness of the spraying materials is very important.* Some older products have no adhesiveness and are washed down by the first small rainfall. Other products, like Bravo have an extraordinarily good adhesiveness.

Under rainy wet conditions, contact fungicides are not sufficient. Large foliage varieties cannot be protected by these products, the whole plant surface is absolutely vulnerable. *Systemic fungicides must be used in this situation.* There are some ingredients and products (Ridomil, Sandofan, Tanos, Forum, ...) that are very effective. Systemic fungicides can stop fungus development even a few days after infection. Contact products do not have this effect.

The timing of spraying is very important. With contact products, the plant surface must always be covered, so it needs a programmed spraying with 10 to 14-day intervals. Systemic fungicides are expensive, programmed spraying is impossible. Spraying time must be a little earlier than the infection, or just a little later. Weather conditions are very important in this situation. *When weather reports predict a longer wet period, the use of systemic pesticides must be as soon as possible.*

Contact herbicides have no or very little hazard to develop resistance. Systemic fungicides represent a much higher hazard. Do not use the same or the related fungicide 3 or more times in a vegetation period.

The useful fungicides see in the next table:

Active ingredient chemical group	Name of active ingredient	Effect method	Name of product	Used rates
Inorganic-metal	Copper	Contact	Astra Copper oxychloride	2.0 – 3.0 kg/ha 0.5 – 1.0%
„	Copper+ Other	Contact + Systemic	Axanit CU 50 WP	2.5 – 3.0 kg/ha 0.7 – 1.0 %
„	Copper	Contact	Bordeaux powder	4.0-6.0 kg/ha 1.0 – 1.5 %
„	„	„	Bordeaux liquid FW	6.0-12.0 l/ha 2.0-3.0 %
„	„	„	Bordeaux mixture DG	4.0-5.0 kg/ha 1.0-1.5 %
„	„	„	Champion 2 FL	1.75-2.0 l/ha 0.4-0.7 %
„	„	„	Champion 50 WP	2.0-3.0 kg/ha 0.5-1.0 %
„	Copper+ Other	„	Cupertine F (M)	2.0-3.0 kg/ha 0.5-1.0 % (M): 4.0-5.0 kg 1.0-1.5%
„	„	„	Cuprofix 30 DG	3.0-4.0 kg 1.0-1.3 %
„	Copper	„	Cuprosan 50 WP	2.0-3.0 kg/ha 0.5-1.0 %
„	„	„	Cuproxat FW	4.0-5.0 l/ha 1.0-1.5 l/ha
„	„	„	Curzate R	2.5-3.0 kg/ha 0.5-1.0 %
„	„	„	Funguran OH 50 WP	2.0-3.0 kg/ha 0.5-1.0 %
„	„	„	Kocide 101 (DF) (2000)	2.0-3.0 kg/ha 0.5-1.0 % (2000): .7-2 kg/ha 0.4-0.7 kg/ha
„	Coppre+ Other	„	Kocide Combi	2.0-3.0 kg/ha 0.5-1.0 %
„	Copper+ Other	Contact+ Local-systemic	Kupfer Fusilan WG	2.2-2.7 kg/ha 0.6-1.0 %
„	„	Contact	Miltox Speciál	0.3-0.5 %
„	„	„	Perotox WP	3.0-5.0 kg/ha 0.7-1.2 %
„	„	„	Pluto 50 WP	2.0-3.0 kg/ha 0.5-1.0 %
„	„	„	Copper sulphate	0.5-2.0 %

„	„	„	50 WP Copper oxychloride	2.0-3.0 kg/ha 0.5-1.0 %
„	„	„	Vitra copper hydroxide	„
„	fentinhidroxiid	„	Brestanid	0.5 l/ha 0.1-0.2 %
Dithiocarbamates	Mankoceb	Contact	Dithane M-45 (DG) (FL)	0.2 % DG:1.0-1.3 kg/ha 0.2-0.3 % FL:1.5-2.0 l/ha 0.3-0.5 %
„	„	„	Manex II.	1.5-2.0 l/ha 0.3-0.5 %
„	„	„	Manzate 75 DF	1.0-1.3 kg/ha 0.2-0.3 %
„	Mankoceb+ Other	Contact+ Local-Systemic	Micexanil WP	2.0 kg/ha 0.4-0.6 %
„	Zineb	Contact	Perocin 80 WP	0.4 %
„	Methiram	„	Polyram DF	1.5-1.8 kg/ha 0.3-0.5 %
„	Mankoceb	„	Vondozeb (plus)	1.4-2.0 kg/ha 0.3-0.5 %
Phtalimides	Captan	„	Captan 50 WP	0.8-1.0 kg/ha 0.15-0.25 %
„	„	„	Merpan 50 WP (80 WDG)	0.2-0.25% 1.25-1.6 kg/ha 0.2-0.25%
„	„	„	Orthocid 50 WP	0.8-1.0 kg/ha 0.2-0.3 %
„	folpet	„	Folpan 50 WP (80 WDG) (48 SC)	2.0-3.0 kg/ha 0.5-1.0 % 1.25-2.0 kg/ha 0.2-0.5 % 1.6-2.4 l/ha 0.4-0.7 %
Organic chlorides	chlortalonil	„	Bravo 500	2.0-2.2 l/ha 0.5-0.8 l/ha
„	„	„	Mycoguard 500 SC	2.2-2.5 l/ha 0.6-0.8 l/ha
„	„	„	Clortosip L (75 WP)	„ (75WP)1.5-2.0 kg/ha 0.3-0.5 %
Other non Systemics	fluazinam	Lokal-Systemic	Altima	0.4 l/ha 0.1-0.2 %
Specific Omycetes killers	Dimetomorf + Others	Systemic	Acrobat MZ	2.0 kg/ha 0.5-0.7%

„	Zoxamid+ Others	„	Electis 75 WG	1.5-1.8 kg/ha 0.3-0.5 %
„	Dimetomorf+ Others	„	Forum R	3.0-3.5 kg/ha 1.0-1.2 %
„	Benalaxil+ Others	„	Galben M ®	2.5 kg/ha 0.6-0.9 %
„	Iprovalikarb+ Others	„	Melody MZ	2.0 kg/ha 0.5-0.7 %
„	Efozit AL+ Others	„	Mikal C 64 WP	4.0-5.0 kg/ha 1.0-1.5 %
„	Propamocarb	„	Previcur 607 SL	0.3-0.4 l/ha 1.3-1.8%
„	Metalaxil+ Others	„	Ridomil Gold MZ 68 WP) (Plus 42,5 WP)	2.5 kg/ha 0.6-0.8 % 4.0 kg/ha 1.0-1.5%
„	Fenamidon+ Fosethyl AL	„	Verita WG	2.5-3.0 kg/ha 0.5-1.0 %
„	Fenamidon+ Others	„	Sereno	1.0-1.25 kg/ha 0.2-0.4 %
„	Propamokarb+ Others	„	Sprint	1.5-2.0 l/ha 0.3-0.6 l/ha
„	Famoxadon+ Others	„	Tanos 50 DF	0.4 kg/ha 0.1-0.15 %
„	Propamokarb+ Others	„	Tattoo	4.0 l/ha 1.0-1.5 %
Strobilurines	Amistar	Local-Systemic	Amistar	0.75-1.0 l/ha 0.1-0.2 %

11. Name of disease: Phoma dry rot

Causal organism: *Phoma exigua* var. *foveata*

The causal fungus is an imperfectly developed pycnidial fungus. This soil fungus is not a quarantine disease in the EU, but it is on the A2 quarantine list of EPPO.

Host range: *First of all the potato, but very rarely detected from sugar beet, spring and winter barley and peas.*

Occurrence and importance: *The fungus is present in the northern, western, eastern and mid-eastern parts of Europe. This fungus likes dry and cool territories, but needs high soil moisture. The pathogen infects the potato plant on the field and finishes the infection and the damage in the storage. The bigger damages are caused by spreading in the storage.*

Symptoms and mistakable diseases:



The fungus causes small brown spots on the basal part and at the base of the leaves of the stem, but this symptom is not well visible in huge plantations. These small spots have more black, very small 0.1-mm spots, they are the imperfect propagating units of the fungus (pycnidia). The tubers have bigger black spots, under the skin there are some caves, which are dry and black with white, later purple mycelia. The stem symptoms may be mistaken for the symptoms of bacterial blackleg or black scurf. These pathogens usually cause wilt, Phoma very rarely causes wilt. Elongated spots caused by Phoma are brown, others are black. The bacterium attack causes a hard smell.

The tuber symptoms are similar to the Fusarium dry rot, but the tuber skin attacked by Fusarium is wrinkled, there are no caves in the tuber, and the white mycelia are outside of the tuber. The Phoma rarely cause wrinkled skins, often causes caves and the mycelia are usually inside of the caves and never outside. Black coloration at the infection is the only common symptom. The Fusarium dry rot causes in the tuber only black coloration, the Phoma at the caves usually causes some pink-purple coloration.

Disease cycle: The fungus overwinters in potato tubers remaining in the soil, free in the soil, or in the infected tubers (sometimes in latent form). The infected seed potato tubers or on the field infected plants develop pycnidia on the stem. The spores, coming out of the pycnidia infect the tubers at the end of the vegetation or during the harvest. The spores use injuries or lenticels as infection gates. Dry, cool storages are good for the mycelial spreading.

The fungus can live for 1.2 years as mycelia in the soil.

Control: Genetic control against this fungus is ineffective, there are no resistant varieties. Certified seed potato material is a good protection method; certified propagation material units are free from this disease. Seed dressing materials can reduce the infection initiated from the infected tubers to a great extent. Only the systemic products have a good effect, registered contact products only have a minimal reducing effect on Phoma dry rot.

Useful products include the following:

Active ingredient chemical group	Name of active ingredient	Effect method	Name of product	Used rates
Carbamates	Pencikurone+ Others	Systemic	Prestige 290 FS	1.75-2.5 l/ha 0.3-0.6 % 60-90 ml/100 kg
„	Karboxime+ Others	„	Vitavax 2000	3.0 l/t

Others	Thiophanate-methyl	„	Topsin-M 70 WP	2.5-3.0 kg/t
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Benomyl has no sufficient effect against this fungus.

Early harvest, avoiding the keeping of tubers in too wet soils for too long times may help to decrease the infection. The tubers, which are continuously in too wet soil, have open lenticels, and it may help for the easy infection.

12. Name of disease: Potato wart

Causal organism: *Synchytrium endobioticum*

The lower fungus lives in the soil, needs the same environmental conditions as the powdery scab, but it is a quarantine disease.

Host range: *The fungus lives on potato, rarely on other Solanum-plants.*

Occurrence and importance: *The potato wart occurs nearly in all states of Europe, rarely in the Mediterranean too. The pathogen likes wet cool conditions. its importance is the quarantine status, the fungus is on the I/A2 list of the EU and A2 list of EPPO plant protection organizations. The durability of the infection in the soil is 30 years, it is similar to cyst nematodes and a very persistent disease.*

Symptoms and mistakable diseases: *The fungus rarely causes symptoms on the green parts, but sometimes at the sprouts, at the base of the stems there is a canker, like a broccoli. The parts, under the soil surface have smaller-bigger tumours similar to a brown broccoli. Young infected tubers are not recognizable; later infected ones develop cankers only at the sprouts. The tumours are white at first then brown-black and finally rot out.*

There are no mistakable, similar symptoms caused by other diseases or pests.

Disease cycle: *The fungus overwinters in the soil as surviving sporangia. Over 8 °C in a wet soil the sporangium develops moving flagellated zoospores, which attack the crop. The zoospores leave the flagellum and go into the cells. The infected cells develop new zoospores and non-surviving "summer" sporangia. This cycle repeats until ambient conditions change. In the autumn, infected cells develop a zygote with merged zoospores. The cell wall covered zygote transform into the surviving sporangium. Spreading is done by soil-infected things, the sporangia are invisible in the soil. The infected seed potato may be infective material too.*

Control: *Chemical control has no chance against this fungus. Use of resistant varieties is the most common control method against the pathogen. The fungus has more physiological types, the 1st is the most common. There are varieties, which have resistance against the other types too. Data about wart resistance are published in the descriptive list of varieties in each state.*

The use of certified seed material is also useful, it is guaranteed by the state to be free.

The prevention of import is very important because of the terrible persistence of the disease. Avoid using alien tools, machines; be careful with the soil contaminated items, like rooted plants, etc.

13. Name of disease: Summer wilt

Causal organism: *Colletotrichum coccodes*

Imperfect developing soil fungus is home nearly in all soils in Europe. The fungus may cause serious yield losses in hot years because it is a typical weakness-disease.

Host range: Potato, rarely other plants

Occurrence and importance: *The soil-fungus lives in all countries of Europe, but usually causes heavy damages in warm territories. The fungus is typically warmth-loving and likes the stressed, weakened plants. Its importance is the increase of damage caused by hot and dry conditions.*

Symptoms and mistakable diseases: *In summer the foliage of the potato wilts, the leaves are yellow. The fungus never infects the leaves, the symptoms are caused by the root-stolon damage. The stolons and the roots dry out, the fungus may cause dead spots on the skin too.*

The tubers have a gum-feeling at touch. On the stolon there is a typical violet-purple coloration and the stolon cannot be distinguished from the tuber. There are bigger brown patches with a lot of small black spots on the stolon or sometimes at the base of the stem. They are the propagation bodies of the fungus.

The wilt is mistakable for a lot of other causal creatures, but the fungus is easy detected and recognized by the purple coloration on the stolon.

The gum-like tubers are similar to the stollbur damage, but stollbur never causes purple coloration and has some other symptoms too (air-tubers at the base of the leaves), which are not present at this disease.

Disease cycle: The fungus overwinters as mycelia, spores or sclerotia (able for continuous overwintering). The pathogen likes warmth between 25 and 30 °C. Weakened, stressed plants are infected by mycelia. Propagation bodies and sclerotia develop on destroyed stolons and on the base of dried stems.

Control: *Good nutrition, water supply and avoidance plant weakness are important. Longer crop rotation periods must be kept after serious damages.*

Basamid-treatment against nematodes significantly decrease fungus density in the soil. There are no resistant varieties against this pathogen.

Seed dressing materials, which are proposed against Phoma dry rot and Fusarium dry rot, are useful against this pathogen too.

No spraying materials are effective, the fungus is not present on the foliage.

14. Name of disease: Powdery scab

Causal organism: *Spongospora subterranea*

Phycomycetous fungus living in the lower soil is not a quarantine pest at present. Water-demanding fungus has importance only in wet parts of Europe, and never does damage in the Mediterranean.

Host range: *The fungus lives first of all on potato, but occurs on other solanaceous plants too.*

Occurrence and importance: *The soil fungus lives in the western and northern parts of Europe, where the Atlantic or coastal climates, or high mountains provide sufficient water for the fungus. The fungus never occurs in the Mediterranean; after import, the pathogen dies due to drought and hot weather conditions. In Central Europe, the fungus survives vegetation only in the mountains. This pathogen has no great importance, causes serious yield losses in extremely wet and infected soils only. The pathogen is first of all a quality damaging fungus.*

Symptoms and mistakable diseases: *The fungus infects the tubers only. On the skin of the potato tuber develops some light coloured spots 1 to 4 cm in diameter, which have a visible border and are slightly erupted. The skin cracks at the top of the eruption in a star-pattern. Under this eruption there is a 1 to 2 cm deep hole filled by dry brown powder.*

The powdery scab is easy to change to the eruptive form of the common scab. First of all the young, not well developed symptoms are mistakable. The common scab has a netted pattern on the eruption, the powdery one has a star-pattern. The powdery scab contains firstly a pulpy, later a powdery material, which is brown. The common scab eruption contains plant tissues only, the thickened skin looks brown.

Disease cycle: *The fungus overwinters as surviving spore-balls in the soil or as infected tuber in the storage. The infected tuber or soil is the infecting source. The surviving spore-balls develop flagellate invading spores, which attack the tubers, using the lenticels. The invasive spores attack the cells, leave their flagellates and walls, they live in the cells as amoeba. After the death of cells, the plasmodia develop a cell-wall and merge into a spore-ball. This is the surviving form of the pathogen, the fine brown powder in the cavern of the infected tuber.*

Spreading is done by infected tuber or by infected soil contaminated parts (tuber, rooted plants, tools, harvesting or other machines).

Control: *Chemical and genetic control has no effective results against this fungus. Seed dressings cannot protect newly developing tubers and there are no resistant varieties (but there are differences between the varieties). Sufficiently long crop rotation, use of uninfected, state-certified seed (it is guaranteed by the state to be free from the pathogen).*

Potato is a very useful method. Nutrition is also important. Too much nitrogen increases the infection rate, potassium dominant nutrition may decrease the infection to a great extent. Prevention of the import of pathogen may be effective on open fields (avoidance of use of alien machines, tools, soil contaminated other items).

15. Name of disease: **Fusarium dry rot**

Causal organism: *Fusarium oxysporum* form. spec. solani

The fungus lives in the soil and may infect all parts of the potato plant under the soil surface. *The pathogen is an imperfectly developing fungus, which has no reproductive body. The conidia and the surviving clamido-spores often occur in every soil.*

Host range: *This special variety lives on the potato, extra rarely on other solanaceous plants.*

Occurrence and importance: *The pathogen is home in nearly all soils, all states in Europe are well infected. The fungus likes dry soil, but often occurs in wet soils too. The pathogen is a typical weakness-parasite. It follows from this status that the fungus attacks plants weakened by extremely wet soils more easily than healthy plants. The fungus infects the tubers and other plant units in the field, the infection may spread in the storage. The acuteness of the infection in bad storing conditions may increase and infection rates may be a little higher during the storing. Yield losses depend on crop rotation, production technology and storage, but may be even up to 70 %.*

Symptoms and mistakable diseases:



The fungus does not cause foliar symptoms, except a moderate wilt at heavy infections. The roots and the stolons are light-brown. This symptom is not divisible from the symptoms of the black scurf. The tuber at the injuries or at the stem end is wrinkled, often with a concentric pattern. The internal part of the tubers is black or dark brown, without purple coloration or mycelia. An often occurring form, when the stem end is infected, is the stem-end rot. Fusarium dry rot is mistakable for Phoma dry rot, but Phoma causes caves in the tuber, the mycelia has a purple colour and it is inside, not outside, like in tubers attacked by Fusarium.

Disease cycle: *The pathogen lives in the soil as mycelia, conidia, under extremely disadvantageous conditions survives as clamido-spores. The fungus infects weakened, stressed plants and needs opened lenticels or injuries for the attack. Stored potato is infected in the field. During the storing, the mycelia infection may increase the infection. The infection source may be the infected seed potato or the infected soil. This fungus is not invasive, spreading may only be fast under very bad storing.*

Control: *Genetic protection against this disease is not complete yet. There are no absolutely resistant varieties, but the susceptibility of varieties is different. Data about it is published in the descriptive list of varieties in each state.*

The use of certified seed potato may be effective, these potato units have a guaranteed, sufficiently low infection rate. *When the soil is heavily infected and the plants are stressed, even absolutely healthy certified seed potato may be infected too.*

Good agri-technical practices and avoidance of stresses are important, healthy plants without stress are very rarely infected.

Do not keep ripe potatoes in the soil for too long periods of time. Some varieties, like Rosara are terribly susceptible to stem end rot, and soil-storing may result total stem end infection.

Seed dressing materials may have some effect, but Fusarium-infected tubers are not available for seed potato. *Infected seed potato units must be selected.*

Crop rotation is very important. When the soil is heavily infected by Fusarium, crop rotation must be longer than 4 years. Some varieties, like Kuroda, which are susceptible to tuber rots, have severe yield losses in normal crop rotation.

16. Name of pest: Common scab

Causal organism: *Streptomyces spp.*

Actinomycetales species live in the soil and are common in European states. The pathogens are classic quality damaging organisms.

Host range: Potato

Occurrence and importance: *Streptomyces specie occurs everywhere in Europe, but prefer warm soils. The damage is higher when the plant is stressed and the soil is periodically dry and wet. The pathogens do not cause heavy yield losses, but the quality is terrible, seriously infected potato units are absolutely unmarketable.*

Symptoms and mistakable diseases:



The soil pathogens are facultative parasitic, attack the potato tubers at the lenticels. *Opened lenticels, caused by too much water in the soil, are more easily infected. Periodic dry-wet conditions in the soil, when these statuses are extreme, may cause serious infections. The skin of potato tuber is locally, firstly at the lenticels rusty. This is difficult to recognize on russet skinned varieties (Russet Burbank, Innovator). This common form may spread on the whole surface of the tuber. Sometimes the pathogen attack indicates a slight tissue growth and might cause 1 to 3 mm high rusty eruptions. It is the rare eruptive form. Rarely the spots, infected by the pathogen, are in little (0.5 to 2 mm deep) holes. This form is the deep scab. Rarely the rusty character is not hard, very slight, but extraordinarily spread. This is the netted form, which is terribly hard to recognize on russet skinned potato varieties. Its importance is „only” the decrease in the value of the potato unit. Seriously infected potatoes are unmarketable, useful only for animal feeding or industrial purposes.*

These pathogens usually prefer alkali soils, but some species survive or need acidic soils.

The common scab in the deep form may be mistakable for the powdery scab. Holes caused by the common scab are shallow and empty. Holes caused by the powdery scab are much deeper, filled by brown powder and covered by the skin, which may have a star-shaped cracking.

Disease cycle: *The pathogens live free in the soil. They multiply by spores, which can survive extremely dry and hot conditions. The pathogens need warm soils for good development and periodically wet soils for the easy attack of the tuber. The mycelia attack the tuber at the lenticels, but the pathogens never attack deeply the flesh of the tuber.*

Streptomyces mycelia are not visible on the infected tuber surface. These pathogens common in the soil are facultative parasitic and can survive some years without potato. The primary infection source is the soil, the infected tuber has no importance, only in the transmission of new species and biotypes between the fields.

Control: *Chemical control has no solutions to the common scab. Streptomyces species and other Actinomycetes are very dense in the soil and responsible for derivation of cellulose and other plant residues. These species are usually susceptible to chemical treatment, but the infection usually begins after the total derivation of the seed potato dressings. Their death can result a sterile, dead soil, which is not capable of plant production. Total soil disinfectants like Nemasol or Basamid reduce their population significantly, but are very expensive.*

The use of non-susceptible varieties is a good method. There are no absolutely resistant varieties, but there are huge differences between the several cultivated potato varieties. Information about variety resistance is published in the descriptive list of varieties in each state within and beyond the EU.

17. Name of disease: **Black scurf**

Causal organism: *Rhizoctonia solani*

The imperfectly developing fungus lives in most soils and is extraordinarily polyphagous.

Typical soil fungus, often occurs in patches and may cause a lot of symptoms, leading to mistakability for some other pathogens.

Host range: *The pathogen is extremely polyphagous, hundred plus hosts are described, but the potato is one the preferred hosts.*

Occurrence and importance: *This soil fungus is common in all states in Europe, but likes warm soils and its density is higher in the southern soils than in other ones. Its importance may be high, it may destroy whole potato fields; yield losses may be high, up to 70 %. The remaining amount is small, covered by small black spots and not really marketable.*

Symptoms and mistakable diseases:

The causal pathogen fungus causes a lot of symptoms and very mistakable with other pathogens. The presence of some symptoms together can only make farmers sure about the black scurf.



The leaf, the foliage wilts, sometimes partially. It may be caused by other fungi, bacteria, nematodes too. Sometimes there is a very slight purple coloration at the top of the plant. The stollbur causes similar coloration which is usually more visible and intensive.

*The witch's broom development, the hatching from the leaf-basal sprouts and the presence of onion-like secondary sprouts-base are similar to stollbur symptoms. The roots are brown, smell like earth, but these symptoms are characteristic to the *Fusarium*, *Colletotrichom*, and the fungal over-infected stollbur too. The tubers have no gum consistence, it is a key distinctive feature from *Colletotrichum* and stollbur. The skin of the tuber is covered by small black, slightly erupting fungal bodies, which are the surviving bodies of the fungus and are characteristic to this pathogen.*



The tuber sometimes has a slight deformation at this scurf, because the fungus decreases the intensity of the growth of the potato tuber. Thus are the "concave" tubers formed, but it may be caused by physiological causes (secondary growth caused by bad water supply) too.

Disease cycle: *The soil fungus lives in the soil free as mycelia, or surviving pseudosclerotia.*

This fungus does not develop spores. Mycelia have a thick wall, pseudosclerotia can survive extraordinary environmental conditions too. The fungus does really not exhaust this chance, because it is extraordinarily polyphagous and can find hosts every year.

Mycelia attack the roots, stolons and tubers. The fungus lives as mycelia in the intercellular holes. Do not need injuries or lenticels for the attack, but prefers stressed potato plants. The key source of infection is the infected soil. Infected seed potato often develops hair sprouts.

Control: *Chemical control by seed potato dressing materials (see at *Phoma* dry rot) is useful against early infection by this pathogen. In a dry spring, seed dressings have a reduced effect because the systemic character is prevented. Early attacks may occur in this situation.*

The use of state certified seed material contains low infection guaranteed by the a state, but it may seriously be infected by the soil. So it is 'second best' solution. Variety-susceptibility is

severe, and there are varieties, which are usually infected in an economically low rate. This variety-character is published in the descriptive list of the potato varieties in all states. Avoidance of stresses, irrigation and good plant nutrition may alone reduce infection rates.

18. Name of disease: Silver scurf

Causal organism: *Spondylocladium atrovirens*

The imperfectly developing fungus is home in every soil, causes smaller-bigger damages everywhere, it is not a quarantine disease and never causes total decline of whole plantations.

Host range: Potato

Occurrence and importance: *The fungus occurs everywhere in the EU and the accession states. Only those fields are free from this fungus in which potato was never cultivated. The pathogen likes cooler and wet soils, but occurs in a lower density in the Mediterranean. The fungus attacks the tubers in the field, but the bad storing conditions may increase the infection. Extremely wet and insufficiently cool storing may result hard infections. The importance is lower than that of other pathogens. Does not cause rots, only the storing losses increase significantly, the tubers are wilted and seriously infected ones develop hair sprouts. The big spots on the surface of the tuber are usually not apparent and decrease the marketability of potato units a little.*

Symptoms and mistakable diseases: *The tuber skin has large lead or silver coloured spots, which are on the yellow skinned varieties light ochre-brown. The spots are not apparent, first of all, on older rusty skinned tubers or on russet skinned varieties (Innovator, Russet Burbank, Shepody). On flat skinned tubers, the spots are reflected when the skin of the tuber is wet. The mycelia, the spores are in an invisible surface on the spots.*

The silver spot is not mistakable for other diseases, only the presence is not apparent.

Disease cycle: *The fungus overwinters in the storage, on the skin of infected potato tubers, deep in the soil on remaining potato tubers and as conidia or mycelia free in the soil. The infection source is the infected soil and the infected seed potato. Mycelia attack the tuber skin, does not need injuries or opened lenticels. The infection may continue in the storage by direct mycelial or by less important conidial spreading.*

Control: *The disease is so common and usually causes so small losses that direct control against the silver spot is not profitable.*

There are some varieties that are have good tolerance against the disease. Information about the resistance-tolerance-susceptibility of the potato varieties are published in the descriptive list of varieties in each state.

State-certified seed potato units contain a small infection rate, it depends on varying state standards. Seed potato, which has a low infection, during bad storing may be seriously infected at the end of the storing.

Seed dressing materials, including Agrocity (3 kg/t), are effective against early soil infections, but have no effect at the end of vegetation, first of all in the mid-late and late varieties.

The use of total soil disinfectants (when it has done against other pests or diseases) reduces the density of the pathogen in the soil very effectively, but such treatment is very expensive.

19. Name of disease: Early blight

Causal organism: *Alternaria solani*

The imperfectly developing fungus is very common, causes foliar losses on hot days of the summer and is often mistaken for late blight.

Host range: *Potato, tomato, rarely other weeds.*

Occurrence and importance: *The disease occurs in the southern and central parts of Europe, because it likes hot, dry conditions. The fungus attacks the leaves and may cause hard leaf destruction. This may initiate new leaf development, which reduces the yield and the dry matter content of the tubers. It is the importance of this disease.*

Symptoms and mistakable diseases:



The pathogen is a typical weakness-parasitic fungus, attacks the leaves in the hot, dry summer when the plants are stressed. The leaves have smaller-bigger dry brown spots, which usually have a characteristic concentric pattern.

The fungus usually begins the destruction on the older, basal leaves, but later occurs on every leaves on the potato plant.

Early blight spots are usually mistaken for late blight symptoms. Late blight causes much bigger spots, has a specific dark green-grey colour, has a hardly visible white sporulation ring around the spots and occurs in wet conditions, but never has a concentric pattern. Early blight causes fast brown spots, no white rings, and occurs in the draught, when late blight causing fungus dies.

Disease cycle: *The pathogen overwinters as conidia in the field, plant residues. Rainfalls help the conidia to touch the foliar surface. When the plants are stressed, the mycelia, hatching from conidia attack the leaf, do not need injuries, but the presence of them helps the infection. The spreading in the leaves is much slower than that of late blight. The fungus develops conidia in concentric rings on the destroyed leaf surface. Dark brown conidia are very resistant to environmental effects.*

Control: *Genetic control is not complete but there are differences in the susceptibility for the early blight disease. Information is published in the descriptive list of varieties in some states. Foliar spraying is effective. All fungicides are useful, which are recommended against late blight, the specific oomycetes killer active ingredients too, when they have a contact partner (for example Acrobat **MZ**, Forum **R**). The oomycetes killers alone are ineffective.*

Timing is less important than with late blight, because the spreading of this fungus is not so fast. At the appearance of the spots on the upper leaves is the best spraying time. The protection of the lower leaves is ineffective and unnecessary.

Pests

The pests damaging the potato are usually visible (except some nematodes), which makes recognizing much easier than that of diseases. Animal pests may cause hard yield losses and a lot of them have quarantine status.

1. Name of pest: Potato cyst nematodes

Yellow potato cyst nematode (*Globodera rostochiensis*)

White potato cyst nematode (*Globodera pallida*)

Both of these species are worldwide spread, often occur together and have quarantine status.

Host range: *The host range of these two pests is common. They can attack the potato, tomato, tobacco, eggplant from the cultivated plants. Solanaceous weeds, like S. nigrum and S. dulcamara are hosts too. Nematodes do not live on pepper, chilli and other capsicum species.*

Occurrence and importance:



The entire territory of the EU is infected by G. rostochiensis, G. pallida does not occur so often, some states, like Finland are free from this dangerous pest.

Both of them have quarantine status; in the EU they are on the list I/A2. As a result of this situation; the potato produced in infected fields is marketable after washing only. Heavy infection by nematodes makes dwarf plants in big holes in the plantation .



Yield losses may be up to 100 %. Nematodes in their recto-parasitic life-stage attack resistant varieties too, and cause smaller (up to 30%) yield losses. Seed potato production is forbidden.

Symptoms: *There are no specific symptoms above the soil surface. Dwarf plants in big long holes are representatives, but they may be caused by other problems too. Some varieties, like Cleopatra (Picture), react with leaf-yellowing but that may also be caused by a lot of things. Some varieties have an early flowering reaction (Tomensa variety), but it is not so impressive.*

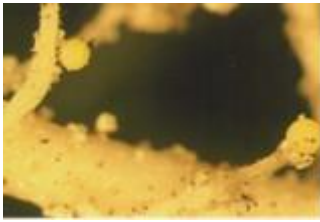


The tubers are much smaller and the yield is much lower than with healthy plants .

The only visible feature is the colour of adult females on stolons and roots. 0.5-mm adults have a yellow colour present on the roots only at the G. rostochiensis attack. G. pallida is more difficult to recognise, its adult females have a white or beige colour and it is not that apparent. Healthy stolons are often similarly coloured.

Cysts are brown at the two species, but invisible in brown soils. The presence of syncytial cells sometimes results a very dense root system. The damage is caused by destroyed roots, disturbed water or nutrient supply.

Description of pest:



Both species are too small for easy detection. Cysts are dark brown, like a fat bottle or a full sack. They are about 0.5 mm and have a very hard wall. The eggs are small, very elongated and contain once deplumated larvae. Larvae and adult males have a normal, worm-like shape, older larvae and adult females have a sack shape. *G. rostochiensis* adult females have a yellow colour, other species a white-beige one. All other forms are white, cysts are dark brown. *The two species have pathotypes, which are very important in the control. Nematodes have 1 generation in central and northern Europe and 2 in the southern states, like Italy.*

Lifecycle: Cysts are laying free in the soil. Eggs are living in this hard walled sack for 40 years. One third of the living material in the cyst is lost every year. Cysts contains 50 to 350 eggs, which contain a deplumated larva. These second-stage larvae are the infective forms. The hatching begins, when the eggs meet the root exudates of the potato. Larvae move max. 20 to 40 cm in the soil, and they can do it in a wet soil only, in a water film. Older Stage 3 and 4 larvae live in the roots. The stage until the invasion into the roots is the ecto-parasitic stage, followed by the endo-parasitic stage. Larvae in the roots form syncytial huge cells, from those feed. In resistant varieties, the development of syncytial cells is blocked, so larvae will be devastated. Stage 4 larvae press out their anal end out of the roots. After the last deplumation, males leave the roots, females stay in the root, but their end is outside the roots. After sexual act, the female body will be differentiated to eggs and the female dies. Cysts fall down into the soil. The potato cyst nematodes have more pathotypes, the yellow has 5, the white has 3. Ro1 is the most common, and a lot of varieties are resistant against them. Ro 1 and 4 have common genetic material, so do Ro 2, 3, 5. So there are a lot of varieties that have Ro 1 to 4 resistance. Pa1 lives in Scotland only, it is a rare pathotype, but there are no resistant varieties against it. Pa 2 and 3 are more common, usually occur together. *Several pathotypes of the two varieties live in the soil together; there is no antagonism between them. The spreading of pests is by the soil or with soil contaminated items (tillage tools, seed potato, rooted vegetables, hard wind, or irrigation water. Cysts move in the soil absolutely invisibly.*

Control: *Chemical control of potato cyst nematodes never results a total effect. Due to their quarantine status, the amount of pests is not important from the point of view of quarantine regulation. Chemical control is very expensive, but necessary when pest density is very high, and ecto-parasitic damage may cause serious yield losses on the resistant variety. There are overall and specific systemic nematicides. Nematicides with total effect are Basamid and Nemasol, which derive are cyanide-cyanate molecules. The active ingredient reacts with water in the soil. Toxic molecules have a gas tension, so the soil must be covered by plastic or irrigated intensively. Basamid is useful between 8 and 20 °C in the soil. At low temperatures the effect is too slow, in high ones toxic gases leave the soil. Basamid use needs soil without crop, plants are killed out by Basamid. Farmers must make a soil test with rape, or other fast hatching plant before planting the crop. Systemic nematicides are very toxic carbamates, like oxamyl (Vydate) or organo-phosphorous materials like phosthiazate (Nemathorin). Granules must be taken into the rooted zone before planting. In early potato production, use is not possible. The use of nematicides may cause 90 to 95 % effectiveness, but G. pallida has a much lower result. Useful nematicides are stated in the following table:*

Active ingredient chemical group	Name of active ingredient	Effect method	Name of product	Used rates
Organo-phosphorous	phosthiazate	Systemic	Nemathorin 10 G	30.00 kg/ha
Carbamates	oxamyl	Systemic	Vydate 10 G	40.00 kg/ha
Others	dazomet	Gas (derivates)	Basamid G	500-600 kg/ha
„	metham-Na	„	Nemasol 510	1200 l/ha

Fumigation with methyl-bromide is useful too, but forbidden in the EU for environmental protection and health issues. *Genetic protection is useful, there are a lot of registered varieties, which are suitable for use in infected fields. For heavy infections, resistant varieties sustain a serious yield loss caused by the ecto-parasitic life-stage, so it must be a chemical use too. Because several pathotypes co-exist in the soil, continuous use of resistant varieties results in a hard selection pressure and finally the appearance of new pathotypes. The most common is Ro1 resistance, so their continuous use may lead to the fast spreading G. pallida. The abortion of potato cultivation is effective of course, but it takes a half century.*

Cultivation of extra early (sensitive!) varieties for extra early fresh potato is effective too, when harvesting precedes end of the pests' lifecycle. To this end, regulation by state authorities is very important, in some states this control is forbidden.

2. Name of pest: Root-knot nematodes

Columbian root-knot nematode	(<i>Meloidogyne chitwoodii</i>)
Pseudo Columbian root-knot nematode	(<i>Meloidogyne fallax</i>)
Field root-knot nematode	(<i>Meloidogyne hapla</i>)
Greenhouse root-knot nematode	(<i>Meloidogyne incognita</i>)
Javanese root-knot nematode	(<i>Meloidogyne javanica</i>)
Sand root-knot nematode	(<i>Meloidogyne arenaria</i>)

Host range: *Root-knot nematodes are substantially polyphagous.* These pests feed on the roots of dicotyledonous crops and weeds. *All of them may occur on potato, tomato, pepper, and rooted vegetables. Instead of them, nematodes attack nearly all present crops and weeds, the first two species some monocot plants (wheat, onion) too.*

Occurrence and importance: Columbian and pseudo-Columbian root-knot nematodes are present only in small locations in Western Europe. *The importance of these pests is their quarantine status, min. 3 generation/year, and the possibility of potato tuber attack.*

Field root-knot nematode is home in Europe everywhere and does not have a quarantine status. It has 2 generations/year (in the northern states sometimes only one), and does not attack the tuber, only the roots, rarely the stolons.

The last 3 species are warmth-loving nematodes, occur in the EU in fields only in the southern Mediterranean. Their importance is the higher number of generations (min. 3). These soil nematodes may seriously contaminate the soil in the traditional potato growing areas, where the crop rotation is shorter, and the changing crops are advantageous for the pests (rooted vegetables). *Attack by these nematodes cause total plant destruction only rarely, but yield losses may be serious, up to 50 %.*

Symptoms: *All of these pests have a common symptom: smaller-bigger tumours on the roots, rarely on the stolons.* These tumours are from the tissue of the plant. The root system is dense, has more than normal lateral roots. Water and nutrition flow is disturbed by the tumours, the plant wilts, first of all, in the hot hours of the day. The size of tumours may be 1 to 20 mm. *M. hapla* often causes great tumours, while *M. incognita* small ones.

Tuber attack caused by quarantine species results a wavy, cankered surface of the potato tuber skin. Tuber attack is usually an escort symptom of root symptoms. The wilt of the plant is a general symptom; it may be caused by several other agents (Stollbur, soil fungi). *The presence of tumours, knots on the roots is a sure-fire way detection of damaging creatures.*

Description of pest: *Root-knot nematodes are so small, that they are invisible, except for the adult female. This form lives inside tumours, but cutting across the tumours, 0.4 to 0.6-mm females occur as small white tear-drops.*

Lifecycle: Root-knot nematodes have a life similar to cyst nematodes. *Eggs in slimy egg-sack or free in the soil overwinter and may survive 4 to 8 years too.* Eggs contain once deplumated larvae, which hatched when the root exudates coming out near the root indicate this process. This second instar larvae are the infecting form. The infection, the movement of larvae needs fluid water in the soil. *The larvae begin firstly an ecto-parasitic life stage, than 2-5 days later go into the tissue of the roots. The presence of larvae initiates the development of huge syncytial cells, which are necessary to the feeding of the pests. These huge cells are responsible for tumours, disturbed water and nutrient supply.*

The next 2 deplumation is inside the plant tissue, in the internal part of the continuously growing tumour. The last deplumation results adult males (they leave the root tissue) and females, the anal ends of which are outside the tumour. *After copulation, the males die, the females continue their life in the growing tumours. Their body-mass transforms, egg development uses up their internal organs. The eggs press out into a slimy egg-sack.*

The spreading by the egg-contaminated soil is very easy. Contaminated seed potato, rooted plants, tillage tools are the transferring things.

Control: Genetic control against these nematodes is absolutely incomplete. *Resistance breeding against quarantine pests has just started in the laboratories of the biggest European breeder companies (HZPC), there are no resistant varieties at the present time. There are resistance sources against *M. incognita*, but not in potato. So in the near future, farmers cannot count on the possibility of using resistant varieties.*

The avoidance of using strange tillage tools, soil contaminated propagation material may prevent import of these pests. The importance of this prevention method is higher in nematode-free fields neighbouring well infected fields.

Crop rotation is very important. The decrease of preferred plants (rooted vegetables, tomato, pepper, cabbage, potato) and the increase of non-preferred plants (wheat, maize, radish, ...) in each year may substantially reduce infective materials in the soil.

There are some plants that kill out these nematodes in the soil. *Oil- radish, mustard, phacaelia (not all varieties!) have a nematicide effect. They develop a large biomass, and its derivates (mustard-oil glycosides and others) are toxic to all forms of these nematodes in the soil. This method is proposed first of all in organic bio-production, but the conventional method may also be useful.*

In case of very high density of nematodes in the soil, chemical control is the best, but also the most expensive solution. Useful nematicides, use methods and rates are identical to cyst nematodes.

The occurrence of quarantine root-knot nematodes initiates hard arrangements by the state plant protection authority. The field will be under quarantine, the yield destroyed. The usable crop assortment will be prescribed and continuously controlled.

The detection of quarantine root-knot nematodes falls outside the scope of responsibilities of farmers, because it is very difficult.

3. Name of pest: Potato moth (*Phthorimaea operculella*)

Host range: Potato, tomato, eggplant, tobacco, beet, nettle, wild solanaceous plants

Occurrence and importance: The pest occurs in the southern states, like Albania, France, Greece, Yugoslavia, Croatia, Malta, Italy, Portugal, Spain, Cyprus, Turkey, Morocco.

Caused by global warming, a slight northern spreading is not impossible. The moth is on the quarantine list of EPPO and some states, which acceded to the EU in 2004.

The importance of this pest is its quarantine status. It is substantially a storage pest, but the later generations may attack the potato in the field.

Symptoms: The leaves are chewed, but not as hard as by the Colorado beetle. The larvae make mines in the leaves and the stems, rarely down the tubers. It is an important symptom that moth chewing is mostly internal, whereas beetle damage is external!

In storage, the upper 1 cm of the tuber surface has more tubes chewed by caterpillars, which never cross each other. The tubes, mines rarely go deep into the flesh of the tuber, like the damage of Elaterid larvae. Presence of a caterpillar damaging the potato may indicate the occurrence of other species (on leaf: *Acherontia atropos*, on tuber: clovers, like *Agrotis segetum*). Other caterpillars have rounded heads (clovers) or damage outside (*Acherontia*).

Description of pest: The causal pest is the caterpillar of a moth. Adults are moths with a wingspan of 10 to 17 mm and a length of 7 to 10, with a non-characteristic grey-brown colour on the first wings.

Adults have extra long antennae, which can reach the end of the abdomen. The eyes are white, in side-light with irisation. The caterpillar is white or creamy coloured. The head is dark brown-red. The first segment on the backside has a similarly coloured lens. The caterpillar head is flat, never round. The pupa is in a silk-cocoon, firstly yellowish white, later brown.

Lifecycle: The caterpillar or the pupa overwinters in the storage or in the southernmost parts of the EU in the fields in a non-visible location. The eggs are on open terrain, on the leaves, stems, tubers, or on the soil near the plant. The larvae live inside the potato plant.

The pest may cause 6 to 7 generations per year, and has no diapause. The pest is warmth-loving, its development stops under 10 °C. Caterpillars live usually in the storage; later generations can spread and attack the potato on the field.

Control: The pest is not seriously invasive, so prevention may be important. Stored potato, tomato units must be checked on the field, if possible. Empty storages are easy to disinfect by fumigation, it takes specially qualified engineers and specific fumigant products. Fumigation may kill out the pest in the stored potato too, but needs higher rate, longer exposition time and is expensive. Empty storages may be disinfected by spraying too. Spraying products with gas tension are much better than contact insecticides. Contact organo-phosphorous insecticides have a lower effect against the hiding caterpillars. The use of pyrethroids has a similar problem and increases the hazard of the storage mites.

The useful products are in the next table:

Active ingredient Chemical group	Name of active ingredient	Effect method	Name of product	Used rates
Organo-phosphorous	Pyrimiphos-methyl	Gas	Actellic 50 EC	1.0-2.0 l/m ²
„	Chlorpyrifos-methyl	„	Reldan 40 EC	0.6-1.1 ml/m ²
„	Dichlorphos	„	Unifosz 50 EC	20 gr/ml

Control on the field needs locally-systemic or systemic products. See useful products in the table for the Colorado beetle. Seed potato dressings and spraying materials are useful too.

5. Name of pest: Colorado beetle (*Leptinotarsa decemlineata*)

Host range: Potato, rarely tomato.

Occurrence and importance: *The continental part of Europe has been occupied for many years. This pest is home in all countries, and the beetle still translates continuously eastward.* The damage is very spectacular; all leaves are fed off, only the base of the main stem remains. The beetle feeds only on the plant units over the soil. Destruction of the leaves indicates a new leaf development, and it needs a lot of assimilates. The potato plant develops leaves instead of tubers. There are chemical controls every year in every country against this pest.

Symptoms: *The leaves are irregularly gnawed (Picture), at serious damages the whole plantation is fed off, only the main stems remain. Due to the heavy leaf losses, the plant has to develop new leaves, and it suppresses tuber development. Yield losses are up to 70 %.*

Description of pest:



The beetle is elongated striped, approx. 1 cm long, with a convex body. The eggs are yellow, like a lemon first, later dark sand colour. The egg stage is 5 to 12 days long, depending on the air temperature. The pest has 4 instar of larvae.

Larvae are pink-orange coloured and very convex. The sides have a black point-line. Larvae and adults are damageable forms too. The pest has two generations in each year.

Lifecycle:

The beetle is the overwintering form, in the soil. The pest has obligate wandering in every spring in an eastern direction. In this stage, overwintered beetles do not look for the host. Only the first generation has this wandering. The beetle cannot fly, but moving on feet is very active. This obligate movement of populations always results the appearance of new, sometimes insecticide resistant populations on the fields. The larvae feed on the foliage like beetles. Extremely hot and dry air rarely controls the young larval population, while longer, cooler and extremely wet weather sometimes reduces the pest population, helping the natural enemies (fungi, nematodes, ...).

Control: *The plant protection against the Colorado beetle based on time is chemical control. There are no resistant varieties against this pest. Genetic protection with built-in genes of endo-toxines of *Bacillus thuringiensis* var. *Tenebrionis* is presently forbidden in the EU.*

Chemical protection has a lot of active ingredients, products and formulae.

Seed potato dressing by neonicotine ingredients, like Gaucho are very effective against the first generation. In very dry conditions, seed dressings cannot relocate into the plant, so the effectiveness will be much lower. Seed dressing is only useful in seed potato and storage potato production, it is forbidden in early fresh potato production.

Spraying materials are plentiful. Organo-phosphorous, pyrethroid, carbamate, neonicotinoid, bacterial, and other active ingredient groups are free for control. Every product is good for a time, after that the indicated resistance prevents good effect. So constant changing of active ingredients and their groups is the basis for protection. *When an insecticide proves ineffective, users must switch to another product from another ingredient group. Adhesiveness, durability and acute toxicity vary by product, but every one has the potential of excellent effectiveness. (Registration would be prevented without it).*

The timing of chemical treatment is very important. Young larvae are more sensitive to insecticides than older ones, while adults are the most tolerant. *The most useful insecticide*

treatment is possible in populations dominated by the youngest larvae. Some insecticides like Nomolt have an effect against larvae only and kill the pest at the next deplumation. Protection is necessary at a hard adult attack; in this case, the application time cannot be modified.

The useful insecticides are the next table:

Active ingredient Chemical group	Name of active ingredient	Effect method	Name of product	Used rates
Organo-phosphorous	Kinalfosz+ Others	Local-Systemic	Chintop	1.0-1.5 l/ha 0.2-0.5 %
„	Metilazinphos	Systemic	Metil-Cotnion 25 WP(20 SC)	1.0 kg/ha (20SC)1.0l/ha 0.2-0.4 %
„	Chlorpyriphos+ Others	Local-Systemic	Nurelle D 50/500 EC	1.0 l/ha 0.2-0.4 l/ha
„	Metylparathion	„	Penncap M	1.5 l/ha 0.3-0.6 l/ha
„	Metidathion	„	Ultracid 40 WP	0.075-0.1 %
„	Phosalone	„	Zolone 35 EC	1.75 l/ha 0.4-0.6 l/ha
Chlorinated carbohydrates	Endosulphane	Contact	Thiodan 35 EC Thionex 35 EC	0.8-1.0 l/ha 0.2-0.3 %
Carbamates	Benfuracarb	Systemic	Oncol 20 EC	1.0 l/ha 0.2-0.3 %
„	Carbaryl	„	Ravion 85 WP	1.5 kg/ha 0.3-0.6 %
„	Dioxacarb	„	Rovlinka 50 WP	„
„	Carbofurane	„	Chinufur 40 FW	0.4-0.8 l/ha 0.1-0.4 %
Synthetic pyrethroides	B-Cifluthrine	Contact	Bulldock 25 EC	0.5 l/ha 0.1-0.2 %
„	Permethrine	„	Chinetrin 25 EC	0.4 l/ha 0.1-0.2 %
„	B-Cipermethrine	„	Chinmix 5 EC/SC/ME	0.3 l/ha 0.1-0.3 %
„	Cipermethrine	„	Cyperil 10 +C	0.4 l/ha 0.1-0.2 %
„	Deltamethrine	„	Decis 2,5 EC	0.3 l/ha 0.1-0.2 %
„	Alfamethrine	„	Fendona 10 EC (2 EC)	0.1 l/ha(0.5 l/ha) 0.02-0.05% (0.1-0.2 %)
„	Lambdacyhalothrine	„	Judo	1.5 l/ha 0.4-0.6 l/ha
„	Cipermethrine	„	Ripcord 20 EC	0.15-0.2 l/ha 0.03-0.06 %
„	„	„	Sherpa	0.1 l/ha 0.02-0.04 %
„	Esphenvalerate	„	Sumi-Alfa % EC	0.3 l/ha 0.07-1.0 %
„	Bifenthrine	„	Talstar 10 EC	0.35 l/ha 0.8-1.0 l/ha
Biological	Bac. thuringiensis	„	Novodor FC	4.0 l/ha 1.0-1.5%

Neonicotinoids	Thiamethoxam	Systemic	Actara 25 WG	80 g/ha
„	Thiachlopride	„	Calypso 480 SC	0.1 l/ha 0.02-0.04 %
„	Imidachlopride	„	Confidor 200 SL	0.3 l/ha 0.04-0.06 %
„	„	„	Gaicho 350 FS	36ml/100 kg
„	Acetamipride	„	Mospilan 3 EC (20 SP)	0.4 l/ha 0.8-1.0 l/ha (0.06-0.1 kg/ha 0.005-0.1 %)
„	Imidachlopride+ Others	„	Prestige 290 FS	1.75-2.5 l/ha 0.3-0.6 % 60-90 ml/100 kg
Development regulators	Chlorfluazurone	Contact	Atabron 120 EC	0.15 l/ha 0.04-0.08 %
„	Hexaflumurone	„	Ekos 100 EC	0.3 l/ha 0.06-0.1 %
„	Lufenurone	„	Match 50 EC	„
„	Teflubenzurone	„	Nomolt 15 SC	0.15 l/ha 0.04-0.08 %
„	Novalurone	„	Rimon 10 EC	0.35 l/ha 0.06-0.1 %
Special feed poisons	Bensulthap	„	Bancol50 WP (500 SC)	0.5-0.7 kg/ha 0.02-0.5 %
„	Cartap	„	Padan 50 SP	1.0 kg/ha 0.2-0.3 %
„	Fipronil	„	Regent 80 WG	25.0 gr/ha
Others	Etofenprox	„	Trebon 30 EC	0.5 l/ha 0.2-0.3 %
„	Abamectine	2	Vertimec 1,8 EC	0.6 l/ha 0.2-0.3 %

6. Name of pest:

Aphids

(*Myzus persicae*)

(*Aulachortum solani*)

(*Macrosiphum euphorbiae*)

And sometimes other species

Host range: These small insects are oligo- or polyphagous, first of all, the most important and most often occurring *Myzus persicae* (green peach aphid). *All species change their host plant in early summer and in the autumn. Their main hosts are trees, stone fruits. The summer hosts are several soft stem plants. Myzus persicae* has a lot of summer hosts, the others only a few, they are “own” aphids of the potato, but have much lower importance than green peach aphid.

Occurrence and importance: *The several species of aphids occur throughout Europe, but there are more when the main hosts (trees) are dense in the country and the weather conditions are not too hot and dry.* The coastal parts in Western Europe and the hot southernmost parts are poor in aphids, caused by continuous western winds or extremely high temperatures.

Direct damage of aphids caused by suction has no importance, water and nutrient losses are negligible. Their importance is virus transmission, which causes the decline of the potato.

Virus transmission may be persistent or non-persistent depending on the virus. All potato viruses, except for the tobacco rattle virus, are transmitted by these insects. The high density of aphids may cause a seriously hard virus infection pressure, which can prevent effective seed potato cultivation.

Symptoms: *Aphid damage has no symptoms, only the presence of the pests signs the damage, which appears in the high virus infection.* Potato aphids do not live in colonies, do not cause leaf or stem discoloration or deformation. The easiest signalisation method is to put a white paper sheet under the potato plant and the shaking of the plant may result aphids on the sheet.

Description of pest: *Aphids are 1 to 4 mm long small insects with elongated soft bodies, the colour of which is light or yellowish green, in hot temperatures sometimes light pink. Larvae and adults are similar, a small part of the adults have wings. Key identification points are the abdominal tubes on the back of the pest. These 2 elongated, dark tubes are only on aphids.*

Lifecycle: These pests overwinter on their main host trees as eggs. During the spring, the first generations make smaller-bigger colonies. *The high density of pests indicates the appearance of winged aphids. They are the invasive forms that fly to the fields looking for useful soft-stem plants. Aphids do their damage during this process, i.e. virus transmission.* Aphids have a lot of generations on these plants during the summer. In early autumn, gynophores, later androphores appear in the population. Gynophores fly back to the main host, and the winged males follow them. It is the only sexual multiplication, the rest is parthenogenesis. Aphids never lay eggs in the summer, they are viviparous, only the sexual act before the winter results eggs. *The spreading of these animals is active; flying aphids find every potato field.*

Control: *The control of aphids depends on chemical control. There are no resistant varieties or agri-technical methods against these pests.* Seed potato dressings are useful in seed potato cultivation, but in terribly dry soils the effect is incomplete. Spraying materials are several, and have to be used before the invasion peak, which may be continuous, long. Potato aphids do not live in colonies in potato fields or on the upper surface of the foliage; they do not deform the leaves, but sometimes are invisible.

A small foliage may be sprayed across effectively with contact insecticides, but the varieties, which develop a huge foliage need systemic products.

Chemical control against aphids is ineffective against the Potato Virus Y, the other mosaic causing viruses and the tobacco rattle virus.

The first two are non-persistent, stylet-borne viruses, and virus transmission is much faster than the effect of insecticides. The last one spreads by free living soil nematode (*Trichodorus*,

Paratrachodorus) species. *The potato leaf roll virus is a persistent virus; aphid control is very effective against this virus. In seed potato cultivation, seed dressing and spraying during invasion time are important to prevent a higher leaf roll virus infection.*

See effective insecticides in the table below:

Active ingredient Chemical group	Name of active ingredient	Effect method	Name of product	Used rates		
Chlorinated carbohydrates	Endosulphane	Contact	Thiodan 35 EC	0.6 l/ha		
			Thionex 35 EC	0.1-0.2 %		
Neonicotinoides	Imidachlopride	Systemic	Confidor 200 SL	0.3 l/ha 0.05-0.1 %		
			„	„	Gaucht 350 FS	36 ml/100 kg
			„	„	Mospilan 3 EC	0.4 l/ha 0.06-0.1 %
			„	„	Prestige 290 FS	1.75-2.5 l/ha 0.3-0.6 % 60-90 ml/100 kg
Synthetic pyrethroids	Bifenthrine	Contact	Talstar 10 EC	0.35 l/ha 0.05-0.1 %		
			„	„	Chinetrin 25 EC	0.4 l/ha 0.06-0.1 %
			„	„	Decis WST	2 pieces
			„	„	Lambdacihalothrine+ Others	1.25 l/ha 0.06-0.1%
„	Lambdacihalothrine	Contact	Karate 2,5 WG	0.3-0.4 kg/ha 0.05-0.1 %		
Organo-phosphorous	Kinalphos+ Others	Systemic	Chintop	1.0-1.5 l/ha 0.5-0.8 %		
			„	„	Dimecron 50	0.05-0.1 %
Specific feeding inhibitors	Pimetrozine	„	Chess 25 WP	0.6 kg/ha 0.05-0.1 %		

7. Name of pest: Wireworms (*Agriotes, Athous, Melanotus, ... spp.* larvae)

Host range: *The wireworms are polyphagous, nearly all plants are hosts for them. Some species have (Athous spp. first of all) a pantophagous character. These animals may feed by saprophagous, phytophagous and carnivorous way.*

Occurrence and importance: *Wireworms occur in every state in Europe. Larvae feed on the roots and make tubes in the flesh of the potato tuber. Their importance is in the quality damage, heavily damaged potato units are not marketable.*

Symptoms: *The worms go and feed across the tubers, the wall of these tubes will later be brown. The tubes go everywhere in the tuber, may even have crossings. There are only small holes on the surface of the tubers. The damage may be in the wet soil secondarily infected by Fusarium or Erwinia, which increases the damage. Potato moth causes similar tubes in the tuber, but moth tubes are near the tuber surface and never cross. The deplumated moth skin is in the tubes at the moth. The two damages are easy to distinguish with some practice.*

Description of pest: *The beetles are 5 to 35 mm long insects with elongated bodies. Their lifecycle is 1 to 4 years. Adults feed on the flowers, first of all, the weed plants from the plant family Umbelliferae and Compositae. The larvae are 3 to 30 mm long, "redskin" coloured, elongated with 3 pairs of feet and with a dark-brown, flat head. The larvae live in the soil.*

Lifecycle: *Wireworms overwinter as larvae in the soil. The lifecycle may be 1 to 4 years, the bigger ones have a longer (Athous spp.) larval stage. Adults are able to fly and usually visit the flowers. The ruderal zone around the fields is an accumulation zone of these pests. The beetles prefer the flowers of Umbelliferae and Compositae weeds. The pests need wet soil surface for egg-laying. Youngest larvae feed mainly on humus, roots and plant units under the soil surface. Larvae attack tubers, rarely stems and chew tubes, mines in them. Presence of these pests needs humus content in the soil. Clear sandy soils for example are less infected.*

Control: *Genetic control is forbidden within the EU, no gene import from Bacillus thuringiensis is useful. Variety control is absolutely incomplete; there are no significant differences between the cultivated varieties. Wireworms, in general, are the pests of neglected fields. Ongoing weed control on the borders of the fields, avoiding the presence of some flowering weeds in neighbouring the field is necessary, and result in a good effect.*

Chemical control may also be useful. Seed dressings and other formulae used in seeding may have a good effect, but some (Carbophurane products) have great environmental hazard.

The total effective soil pesticides (Basamid, Nemasol) have very good effectiveness, but have no effect against the later invasion. When using them, the soil must be controlled by soil tests (without crop!) because the derivatives of these products are toxic for the crops too.

Useful insecticides are the following:

Active ingredient Chemical group	Name of active ingredient	Effect method	Name of product	Used rates
Organo-phosphorous	Diazinon	Systemic	Basudin 5 G	35 kg/ha
„	„	„	Diazinon 5 G	„
„	„	„	Diazol 5 G	2
„	Phosthiazate	„	Nemathorin 10 G	30 kg/ha
„	Terbuphos	„	Counter 5 G	20-25 kg/ha
Carbamates	Carbophurane	„	Chinufur 40 FW	4.0-6.0 l/ha
„	„	„	Furadan 10 G	15-20 kg/ha
„	Phorate	„	Thimet 10 G	„
„	Oxamyl	„	Vydate 10 G	„
Syntethic pyrethroides	Tefluthrine	Contact+gas	Force 10 CS	1.0-1.5 l/ha
Neonicotinoides	Imidachlopride	Systemic	Confidor 200 SL	1.75 l/ha
„	„	„	Gaucho 350 FS	36 ml/100 kg

„	Imidachlopride+ Others	„	Prestige 290 FS	1.75-2.5 l/ha 60-90 ml/100 kg
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8. Name of pest: Soil caterpillars (*Agrotis*,*spp.* larvae)

Host range: *The caterpillars of the clovers are polyphagous, all soft stem plants may be hosts.*

Occurrence and importance: *The pests are home throughout Europe. The most common one, *Agrotis segetum* is a little more dense in the eastern parts. Their importance is the quality damage done by chewing caves in the tuber. In wet conditions, the injuries may initiate *Fusarium* or *Erwinia* attacks, which may increase the damage.*

Symptoms:



The tubers have a big cave of an irregular form. Sometimes the caterpillar is visible in the cave or near the location of the damage. The base of the stems is rarely chewed around, the foliage wilts. The caterpillar is near the new damage.

Description of pest: *Adults are 15 to 40-mm butterflies, the front wings have special patterns, which are usually not visible. The most common *Agrotis segetum*'s wings are dirty grey-brown, only recently hatched butterflies have a pattern. The caterpillars are 3 to 40 mm long, grey-brown, soil-coloured, stubby animals, with a big, rounded head. The caterpillars hate light; live in the soil and move to the soil surface only at night.*

Lifecycle: *Agrotis segetum is the most common damaging pest of this group. For this species, the last stage of the caterpillars is the overwintering form. When the autumn is long and warm enough, the caterpillars have a plus one (the seventh) instar of larvae. Other, rarer clovers have other overwintering methods. *A. segetum* has 2 generations per year, and both of them may damage the potato. The first damages are in late spring, early summer, the second one in late summer and during the autumn. The second generation has much bigger population and usually causes bigger damages. The caterpillars live in the soil, because they do not like light. At night, they may travel bigger distances (10-20 m per night) on the surface. Spraying materials can only reach them during this time.*

Control: *Genetic control provides no solution against these pests.*

Chemical control has a good effect against the first generation; against the second one the products lose their effectiveness. Seed potato dressings and soil disinfectants used against wireworms are also useful against soil caterpillars, but with no effect in the autumn against the damaging second generation.

Younger larvae are more susceptible to insecticides than older ones, so the good timing is very important. Spraying in the middle of the night with effective toxic insecticides (Chlorinated carbohydrates, locally-systemic organo-phosphorous insecticides and synthetic pyrethroides, see Colorado beetle) may result in very effective control.

At the signalization, the base of the stems needs to be supervised. The damage is often in large spots, the spreading is usually in the front line. The absolute disperse occurrence is the typical of not damaging, very low density. Checking for larvae gives important information about the infected parts of the field and the size of larvae.

At the spraying, the spraying material volume must be as high as possible. The product must reach the body of caterpillars in motion. Great foliage makes a big problem since an extremely high volume of spraying solution must be used (1000 l/ha if necessary).

Weeds

The presence of several weeds on the potato field or in their vicinity may cause several problems both directly and indirectly.

Weed plants initiate a hard competition, a race between them and the crop plants for nutrients, water, sunshine and living space. This is an indirect damage, the weeds do nothing with the crop plants, just win the race for these things. Some weeds are higher than the most emerging stem system potato variety, and catch the sunshine and the leaf area away from them. The weed plant roots have a much bigger suction capacity, so they win the race for nutrient elements and water in the soil.

Weed plants may also cause direct damages. *Some species like quick-grass (Agropyron repens) have terribly spiked stolons and can grow across potato tubers. This damage manifests in unmarketable potato units, and sometimes may initiate bacterial or fungal infection in the field and in the storage too. The foliage and root biomass of the weeds may cause serious problems at the harvest and may lead to a high harvest loss.*

The weeds are also hosts to several diseases and pests. Bearbind (Convolvulus arvensis) is a host to stollbur phytoplasma, wild Solanum weed species are hosts to quarantine pest cyst nematodes (Globodera rostochiensis and Globodera pallida). Ruderal zones around the fields are good feeding territories for some polyphagous pests like Elateridae beetles and clovers.

Do not put up with the presence of the weeds either in the fields or in their vicinity.

The potato is not a well-known weed-host crop, because of its own weed-suppressing ability, and relatively simple weed control.

The potato has more soil tillage at the beginning of vegetation and its weed-killing effect is very effective. The build-up of primary hills at the seeding, than the build-up of secondary hills after emergence destroys the whole soil surface in the field and kills all weeds, which have hatched until that time.

The potato plant, depending on the cultivated variety, has large foliage, which also has a weed-suppressing effect. The variety effect is important in this case. Early varieties, which have small foliage only, like Agatha, Frieslander have no effective weed-suppressing character. Varieties developing extra large foliage (usually later ones that have a capability for continuous vegetative growth, like Cornado) have very good weed-suppressing effect and are usually more free from weeds than other varieties.

1) Name of the weed: Jimson weed (*Datura stramonium*)

This annual weed is not typical plant on the potato fields, but sometimes may cause damages in the potato too. The whole plant is dangerously poisonous. It has a large body and by the shadowing of the crop at the second half of the vegetation period can cause yield losses and problems at the harvest.

Biology:



This is an annual, dicotyledonous weed; its life form is T4.

Germination period: From end of May, continuous.

The weed likes the neutral, cultivated soil, and the high and Nitrogen dominant nutrition.

Cotyledons: They are extremely long with short petiole. The cotyledons' colour is not as dark green as the other leaves are.

Foliage leaves: The leaves are big, shining and deeply serrated.

Plant: very large, about 1m high. It can grow over the crops.

Flower: Large, white, tubular, like the end of a trumpet. The base of the flower is covered around a green tubular calyx.

Flowering period: From the end of June till the first frost.

Fruit: Big, internally separated capsule, its external surface is dark green and spiny, with a very well visible short collar.

Seeds: Relatively big (thousand seed weight is 6-8 gram), black, slightly granular, bean shaped.

Seeds per plant: about 3000.

Summary: The weed overwinters in seed form and usually attacks those crops, which is grown with wide row spacing. The late germination and the late occurrence in the crops may cause control problems.

Occurrence and importance:

The weed occurs in all over Europe, except for the northern countries. The weed likes the warm, light conditions; therefore it is much more widespread in southern, middle and east Europe. This poisonous weed extremely likes Nitrogen, it is an indicator plant.

It may shadow the crops, the great volume of weed foliage may cause harvesting problems and the poisonous units of the plant can cause animal and human health problems.

Control:

Usually the control of Jimson weed in the potato is easy, the relative potassium-dominant nutrition of the potato, the natural weed-depressing effect of the big foliage potato varieties and the usually applied metribusine ingredient keeps this weed from the potato fields away.

Agrotechnical control: The potatoes' own weed depressing feature is effective enough against the Jimson weed. In case of early varieties the weed cannot have enough time for developing large foliage caused due to the early harvest. The potato varieties with large foliage depress the Jimson weed effectively, the weed only have life area at the late season of the potato's lifecycle. Therefore pay attention, which variety you use.

The balanced, potassium-dominant nutrition of the soil usually prevents the problems of Jimson weed.

Mechanical control: There are no too many possibilities of mechanical control in the potato field. The building up of second hill usually come earlier than the hatching of Jimson weed. At the late varieties in case of late planting this mechanical control (the building up of second hills) can prevent the earliest hatching but usually has to be combined with chemical control.

Chemical control: The Jimson weed is not a problematic weed in the potato. The most commonly used chemical is Sencor or relative herbicides with metribusine active ingredient can kill out this weed absolutely.

The divided application (pre and post) of metribusine ingredient gives a good, long effect on the late hatching plants of the Jimson weed (in early season varieties, varieties with small volume of foliage).

The potato is usually resistant to metribusine, but some varieties, like Frieslander, Vitesse are sensible. In case of these varieties do not use post treatment and in pre treatment use the minimal rate.

The Sencor is the basis in weed control of the potato, but may combine with these other proposed herbicides to have a better effect.

The useful herbicides in the potato are the following:

Active Ingredient	Name of the Product	Effect method	Application method	Dosage	Controlled Weed groups
Chlomazone	Command 48 EC	Systemic	Pre	0,15-0,2 l/ha	Annual monocot and dicot weeds
Promethrine	Merkazin	“	“	1,75-2,6	Annual dicot weeds
“	Gesagard	“	“	kg/ha	
“	Prometrex 50 WP (500 SC)	“	“	2,0-3,0 kg/ha (1,5-2,5 l/ha)	
Terbuthrine+ Metolachlor	Igran Combi Gold 450 EC	“	“	5,0-7,0 l/ha	All annual monocot and dicot weeds
Linurone	Linurex 50 WP	“	“	1,5-3,0 kg/ha (Depending on the humous content of soil)	Annual dicot weeds
Pendimetaline	Panida 330 EC	“	“	4,0-6,0 l/ha	Annual dicot and monocot weeds except Malvaceae, Solanaceae
“	Stomp 330 (400 EC)	“	“	4,0-6,0 l/ha (3,5-4,0 l/ha)	
Metribusine	Sencor 70 WP	“	Prae Post	Prae: 0,6-1,2 kg/ha Post: 0,4-0,6 kg/ha	All annual and perennial weeds, except the very deeply rooted G ₃ weeds
Metribusine+	Plateen	“	Pre	2,0-2,5 kg/ha	Annual

Fluphenacet	41,5 WG				monocot and dicot weeds
Fluor-chloridone	Racer	Pre	Contact	2,0-2,2 l/ha	All annua weeds, except the very waxy, haired, or covered cotyledonous weeds
Rimsulph-urone	Titus 25 DF	“	Systemic	40-60 g/ha	Annual and perennial monocot and dicot weeds

**2) Name of the weed: Ragweed /Ambrosia/ (Ambrosia artemisifolia)
Synonym: (Ambrosia elatior)**

This annual dicotyledonous weed is well known all around the world about its hard allergy initiating character. It occurs on ruderal territories, fields, field borders; typical pioneer weed. In the second part of the vegetation period may develop a large phytomass and can cause sometimes harvesting problems.

Biology:



This plant is an annual, dicotyledonous weed; its life form is T₄.

Germination period: From the end of April till the beginning of the summer draught.

The weed likes the cultivated soil, but it does not need high nutrient level.

Cotyledons: Medium green and slightly haired, short, oval.

Foliage leaves: Medium green deeply separated, slightly hairy.

Plant: From a few cm to 1,5 m high, the stem system is well branched.

Flower: Very small, normally not visible. The extremely small flowers are organized into emerging twigs, the flowers are hanging. The more, than 10 cm long twigs contain hundreds of flowers in more rows. Flowering begins at the base of the twig and finishes at the peak. The flowers develop a lot of very allergy causing, orange-beige coloured pollen. From this pollen the flowering ragweed has a special, peachy green colour. The plant is a member of the plant family Compositae, but it does not look like a typical member of this family.

Flowering period: From the end of July, continuously till the frosty days.

Seeds: Small, green seeds, its weight is about 1 gram. The seed is long-oval, with a peak and in the middle part has a crone around of the base of the peak. These eruptions may be destroyed in the soil.

Seeds per plant: about 5000.

Summary: This weed overwinters in seed and may attack every crop on the field. Its late germination may cause problems in the second half of the growing season. The young plants

can develop under the shadow of the crop, than later overgrow them. Because this weed is absolutely common, the infection pressure is high, so the weed control has to be continuous.

Occurrence and importance: It likes the southern, middle and eastern parts of Europe, so it is a warm-like weed. In other parts of the EU it may be found only in sporadic form. This weed occurs on the fields, the field borders and on ruderal territories too. It prefers cultivated soil. Its importance originated from its effect on human health and its water-nutrient competition with the crops.

Control: The usually used herbicides containing metribusine as active ingredient, like Sencor have a good effect and endurance against the weed. On well infected fields the distributed Sencor application (pre and post) can provide good prevention against the continuously hatching weed. When the potato foliage is destroyed in the middle of the summer, meanwhile the weather is rainy and the harvest will be later, there is a hazard of late weeds attack. It is a technological mistake that under this weather condition the potato is still kept in the soil, since all these conditions may result in bacterial or fungal (Fusarium) attack. This late weed attack may be treated with total herbicides, when the old potato plants do not have green parts. The usage of the total herbicides, like products containing glyphosate are useful in this case, but the best solution is to harvest as soon as possible.

The useful herbicides are the following:

Active Ingredient	Name of the Product	Effect method	Application method	Dosage	Controlled Weed groups
Chlomazone	Command 48 EC	Systemic	Pre	0,15-0,2 l/ha	Annual monocot. and dicot. weeds
Promethrine	Merkazin	“	“	1,75-2,6	Annual dicot. weeds
“	Gesagard	“	“	kg/ha	
“	Prometrex 50 WP (500 SC)	“	“	2,0-3,0 kg/ha (1,5-2,5 l/ha)	
Terbuthrine+ Metolachlor	Igran Combi Gold 450 EC	“	“	5,0-7,0 l/ha	All annual monocot and dicot weeds
Linurone	Linurex 50 WP	“	“	1,5-3,0 kg/ha (Depending on the humus content of the soil)	Annual Dicot weeds
Pendimetaline	Panida 330 EC	“	“	4,0-6,0 l/ha	Annual dicot and monocot weeds except Malvaceae, Solanaceae
“	Stomp 330 (400 EC)	“	“	4,0-6,0 l/ha (3,5-4,0 l/ha)	
Metribusine	Sencor 70 WP	“	Pre Post	Prae: 0,6-1,2 kg/ha Post: 0,4-0,6 kg/ha	All annual and perennial weeds, except the very deeply rooted

					G ₃ weeds
Metribusine+ Fluphenacet	Plateen 41,5 WG	“	Pre	2,0-2,5 kg/ha	Annual monocot and dicot weeds
Fluor- chloridone	Racer	Pre	Contact	2,0-2,2 l/ha	All annual weeds, except the very waxy, haired, or covered cotyledonous weeds
Rimsulph- urone	Titus 25 DF	“	Systemic	40-60 g/ha	Annual and perennial monocot and dicot weeds

3) Name of the weed: **Redroot pigweed** (*Amaranthus retroflexus*)

This weed is very common dicot weed in the potato fields. It may develop resistant races, so may be dangerous and problematic at the control. There are some other pigweed species, like the high pigweed (*Amaranthus chlorostachys*), but everywhere the redroot pigweed is the most common.

Biology:



The weed is a typical late-summer weed, its life-form is T₄. It may grow very high, up 1,5 m and develop a terrible large green biomass. It gives a very hard competition with the crop for the water and the nitrogen.

Germination period: from begin of the summer till the middle point of the autumn. The plant is high, the stem system is erected, the whole plant is well, crude haired, so the leaves and the plant has a little bloomy coloration. The leaves are middle oval, well haired, dark green. The flowers are in a complex inflorescence, which is well visible haired. The inflorescence is creamy, light green. The seeds are small, 0,5 mm great, flat, black, shining. The weed plant may develop 1000 – 6000 seeds.

Occurrence and importance: The weed occurs in the warmer parts of Europe, likes the well nutrified soils, but independent from its physical constitution. The weed plant may be very high, can overgrow the crop and may develop a very dense, large green biomass. It needs a lot of water, nutrients and may cause sometimes harvesting problems. The pigweed usually develops resistant races against some herbicides, so the continuous weed signalization and the herbicide rotation is very important.

Control: The redroot pigweed is a dangerous weed, the agrotechnical, mechanical and chemical methods alone usually cannot control them.

Agrotechnical control: The good quality of the seed, the sowing and the base-nutrition is very important for the control. When the crop starts its life optimally, the pigweed cannot reach a bigger depressive effect. The agrotechnical mistakes, or other problems may depress the young development of the crop and in this case the pigweed can overgrow it.

Mechanical control: The building up of the secondary hill destroys the firstly hatched weeds. The later hatching may dangerous on fields, where a very early variety was planted and its foliage is relatively small.

Chemical control: The herbicides, which are recommended against the jimson weed are usually effective against the pigweed too. Because this weed may develop resistant races, the products and the used active ingredients must be continuously change.

4) Name of the weed: Fat hen (*Chenopodium album*)
Synonym names: Common lambsquarter /Meldweed

Biology:



Annual, monoecious, seed-propagated weed with a strong taproot. Young parts of the plant farinaceous. On almost all soils, preferring friable, nitrogen-rich, humus-rich loamy and sandy soils.

Germination period: late spring-autumn.

Cotyledons: long, slender, rounded in front, reddish underside, farinaceous.

Foliage leaves: oval to triangular, longer than wide, long-petiolate, tapering toward the petiole, light blue-green, unevenly dentate, but first leaf pair uppermost lanceolate leaves entire.

Stem: blunt-cornered, erect-ramified, up to 150 cm high.

Flower: inconspicuous, greenish, in dense axillary glomerules.

Flowering period: midsummer-autumn.

Seeds per plant: 3,000 (200 - 20,000).

Occurrence and importance: This weed is a typical weed of the continental climated parts of Europe. If the soil is rich enough in nutrients the body of the weed may be extraordinary large and may overgrow the normal crop plants. This hazard increases, when the crop variety has a relative short vegetation period. The large green biomasse of this weed may cause harvesting problems too.

Control: This weed is usually non problematic in the potato, but can develop resistant biotypes, when some herbicides are used in bad dosage, or without any rotation every year.

Cultural control: crop rotation, rotation of crops and cropping.

Mechanical control: The mechanical tillage of the soil surface between the rows (the building up of the first and second hill) gives a good effect till the end of June. On very well contaminated fields the very deep ploughing may result a temporary effect.

Chemical control: This weed species is usually sensitive to the used herbicides, but continuous usage of one material may result the appearance of the resistance. The herbicides, which are published in the tabelle at the jimson weed are well effective against this weed species too.

5) Name of the weed: Sunflower (Helianthus annuus)

This weed-crop occurs everywhere in the European fields and causes weed problems in all crops.

Biology:



The plant is annual, its life form is T₄. The plant is very high, up to 2,5 m ! Germination period is extremely long, from April to August. The late hatching causes the biggest problem. The leaves are big, heart-shaped, well haired. The flower is great, well known, great, yellow plate. The seeds are big, 4mm – 20 mm, their surface is black, or striped. The seeds can lay in the soil for more years. The flowering period is long, from end of June till September.

Occurrence and importance: The sunflower occurs in every soils, where only once it was cultivated. Do not need extreme things about the soil physics, nutrition, climatic condition. It is a typical culture-weed. The late hatching of the laying seeds may cause problems in the potato. The weed grows over the crop and gives a very hard competition for the water and the nutrients. The earlier varieties, and those ones are under bigger hazard, which develop smaller foliage (f. eg. Frieslander). The great green biomass of the weed may cause harvesting problems too, the flowering weed accumulates the aphids.

Control: The sunflower is a dangerous weed in the potato cultivation. The several control methods alone do not result a good effectivity.

Agrotechnical control: The early planting and the development of a great enough, dense crop-foliage is important, it can prevent well the serious weed hatching and development. The avoidance of the extreme infected fields is well useful too.

Mechanical control: The building up of the second hill destroys the weeds, which are hatched till this time. After that there is no chance with mechanical way.

Chemical control: The usual used herbicides, which are in a table at the jimson weed are useful against the sunflower, but the effectivity is sometimes too low. The distributed Sencor treatment and the Titus have the greatest effectivity. Their post application gives a high enough effect against the late hatching weed plants.

6) Name of the weed: Dodder (Cuscuta campestris)

The dodder is an absolutely polyphagous, parasytic weed, which may occur in the potato too. Not typical weed of potato.

Biology:



The weed's life form is T_4 , but the parasytic life method is the typical for this plant. The hatching period begins in June and ends at September. The whole plant is gold-yellow coloured, without any green colour. The plant looks as a big hank of wires with a lot of small globose knots. These knots are the flowers. The seeds are very small, about 0,2 mm small, round formed and yellow, with shining surface.

The seeds begin to hatch by the root exudates of dicot plants, the young stems look actively for the host plant.

Occurrence and importance: The dodder may kill out the potato plants, but the damage is usually not high in the potato field. The big living phytomasse may cause harvesting problems too. This weed occurs usually on the ruderal territories, spreads by its very small and light seeds and during the vegetation actively and mechanically too by its broken down parts.

Control: The continuous signalization of the weed is very important. After the recognizing of the dodder in the field, the infected spots have to be killed out mechanically, or by usage of total herbicides. The weed control must do on the ruderal parts too. The earliest detection of the weed is very important, so with small damaging may prevent a much higher weed damage.

Annual monocotyledonous weeds

Name of the weed: Barnyard grass (Echinochloa crus-galli)

This weed species has got cosmopolitan occurrence. Prefers the humid soils and the high nutrient level.

Biology: Annual monocot grass, its life form is T_4 .

Germination period: late spring – begin of summer. Site and soil: Mainly sandy soils, but occurs on heavy soils too. Likes the humid soil, with high nutrient level.

Foliage leaves: They are glabrous, the ligule is substituted by hairs, auricle absent. Plant: 10 – 100 cm high. Flower: Compressed panicle is green to red-brown, often overhanging. The spikelets are 3-4 mm long, lemma mucronate or awned.

Flowering period: From June till end of autumn. Seeds: 2 mm long, yellow – brown, smooth. Seed production. 1000 – 4000/plant.

Occurrence and importance: This large, annual grass occurs everywhere in Europe, where humid and rich soils are there. Occurs often in the segetal and ruderal habitats, often attacks the potato fields too. The weed gives a very hard competition for the nutrients and can press down the potato varieties, which have a small foliage in the vegetative growing period.

Control: This weed grass causes sometimes problems on the potato fields. In case of extreme hard contamination the control on field without crop may be necessary, or specific monocot killer herbicides must be used. The usual, or lower contamination is easy to control by the often used active ingredient metribusine, but the higher rate have to be used and the effectivity will be not high, first in all against the older weed plants.

Mechanical control: The continuous mechanical tillage of the potato fields by the hill-buildings till the end of June may prevent the higher damages. Later the potato can prevent the high growth of the weed, except the earlier and the small foliage developing varieties.

Agrotechnical control: The plantation must be compact, with stable density and without holes.

Chemical control: The chemical control of the barnyard grass is not too problematic, but in dry conditions the pre herbicides result usually a reduced effect. This weed can develop resistance, so the continuous rotation of the herbicides is important,

The useful herbicides are the following:

Name of the Active ingredient	Usage method	Name of the product	Used rates
Acetochlor	pre	Acenit 50 EC	4-5 l/ha
"	pre	Guardian EC	2-3 l/ha
Metolachlor	pre	Igran Combi	5-7 l/ha
Propisochlor	pre	Proponit 840 EC	1,5-2,5 l/ha
Pendimethaline	pre	Stomp 400 SC	3,5-4 l/ha
Rimsulphurone	pre/post	Titus Plus	307 g/ha
Metribusine	pre/post	Sencor 70 WG	0,8-1,2 kg/ha
Cycloxdime	pre/post	Focus Ultra	1,0-1,5 l/ha
Butylfluazyphop	post	Fusilade Forte	0,8-1,2 l/ha
Tephurylquizalphop	post	Pantera 40 EC	0,8-1,5 l/ha

Perennial monocotyledonous weeds

Name of the weed: Sedge (Carex spp.)

There are some sedge species, which can occur on the potato fields and sometimes cause harvesting problems in the potato cultivation.

Biology: The sedge is usually G₁ life form weed, its size, external habitat, occurrence period, emergence depth depends on the species. The plant occurs usually in clumps. Their leaves are extremely long, often semi-tubular, rarely flat, fine haired. The flowers are very small, compressed into an ear. The spreading occurs on the fields usually by the stolons.

Occurrence and importance: The sedge occurs everywhere in the EU, where the soils are acidic, wet enough and the roots and rhizomes can develop deep enough into the soil. Often occurs on the fields, which are in the valley of smaller rivers, or at the marshlands. The sedge develops sometimes large clumps, the great green biomass may cause harvesting problems and at the clumps causes total yield losses.

Control: Agrotechnical: The layout of the potato fields is very important. The avoidance of the deepest, infected fields is useful. The earlier planting is useful too. So the dosage of herbicides may be more free, than at the later planted fields.

Mechanical: The mechanical method is ineffective against the sedge, it hatches sometimes after more days the building up of the second hill.

Chemical: The usually used metribusine active ingredient is ineffective against the sedge. The specific monocot herbicides are useful. The best method for the control the usage of total effective herbicides, like Glialka, or Glyphos on field, without crop.

The useful monocot killer herbicides are the following:

Name of the Active ingredient	Usage method	Name of the product	Used rates
Cycloxydim	pre/post	Focus Ultra	3,0-4,0 l/ha
Butylfluzoxyp	post	Fusilade Forte	2,6-2,8 l/ha
Tephrurylquinoxaloph	post	Pantera 40 EC	2,0-2,5 l/ha
Haloxyp	post	Perenal	1,5-2,0 l/ha
Chlortolpyr	post	Select Super	2,0-2,4 l/ha
Ethylquinoxaloph	post	Targa 10 EC	2-4 l/ha

The treatment has to be done onto a great enough green surface of the weeds!