Food and Agriculture Organization of the United Nations

Good agricultural practices and technologies to mitigate the impacts of natural disasters in oilseed rape production in Serbia

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Contents

Rationale

Natural disasters, such as droughts, extreme temperature fluctuations, floods, and stormy winds, have gradually intensified in the past years. It is expected, due to climate change, that these disasters will become more frequent and pronounced. According to the Second Biennial Updated Report and the Third National Communication of the Republic of Serbia submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2019, the Republic of Serbia is among the most endangered European countries in terms of natural disasters and climate change.

Agriculture is one of the sectors most dependent on climate so is very sensitive to variation in environmental conditions and climate change. Agriculture activities and the people depending on this sector can be significantly affected by climate change. Thus, the Republic of Serbia's economy is affected since the agriculture sector greatly contributes to gross domestic product (GDP) and provides employment to many rural people.

The Serbian Ministry of Agriculture, Forestry and Water Management (MAFWM) wants to increase the readiness of oilseed rape producers and other agricultural producers to mitigate the impacts of natural disasters and climate change. Therefore, the MAFWM turned to the Food and Agriculture Organization of the United Nations (FAO) to support the development of guidance documents for farmers addressing practices and technologies that reduce the impact of natural disasters and climate change. As part of that process, a panel of Serbian oilseed rape experts gathered at an initial workshop held on 24 September 2020 to discuss existing knowledge and practical solutions in this area.

The panel of experts included representatives of the MAFWM, universities, research institutes, the Hydrometeorological Institute, agricultural advisory and professional services, farmers' associations, oilseed rape producers, and private companies. The conclusions and recommendations from the workshop are summarised in a draft prepared by Ana Marjanović Jeromela and Slaven Prodanović. At the second verification workshop held on 28 October 2020, the draft was reviewed and supplemented with expert suggestions. This brochure was derived from these workshops, and it contains all the identified good agricultural techniques and innovative technologies that can help build the resilience of the agricultural sector, and especially of oilseed rape producers, to mitigate the effects of natural disasters and climate change.

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The importance of oilseed rape

Oilseed rape (*Brassica napus* L.) is mainly grown to produce a seed rich in oil (40–48 percent) and proteins (18–23 percent). It is the third source of vegetable oil and the second largest source of protein flour in the world. It is also important as an alternative energy source in the biofuel industry. Due to the high content of essential unsaturated fatty acids, oilseed rape stands out from other cultivated oil plants. In the spring, the flowering of oilseed rape is important for bees as it represents the first pasture. At the same time, oilseed rape has a great potential to produce fresh (green) fodder in the nutrition of ruminants. The average yield of green fodder in agro-ecological conditions of northern Serbia in larger production areas is about 40 t/ha in winter and about 30 t/ha in spring varieties. In addition, it is considered useful as cover crop. The use of oilseed rape as a green manure is also recommended in organic agriculture. Oilseed rape improves the quality of the soil, and due to its long spindle root, it can use nutrients from deeper soil layers. Since it covers the ground for almost a year, it is important for reducing soil erosion and suppressing weed growth.

In the agro-ecological conditions of Serbia, it is possible to grow both winter and spring oilseed rape, but the winter form has a higher yield compared to the spring, which is grown mostly for specific purposes. In recent years, there has been an increase in the area under this crop in Serbia. However, seed yield is unstable and varies from 2 t/ha to 3.2 t/ha, depending on the year, i.e. weather conditions during the vegetation period (see Figure 1).

Agro-ecological conditions for oilseed rape growth

For productive growth and development, rapeseed plants require appropriate conditions. Farmers must know the optimal needs of oilseed rape for the most important agro-ecological factors. The requirements of oilseed rape for soil, light, temperature and water are described below.

Emerging oilseed rape plant.

Soil

Oilseed rape grows well in many types of soil. It grows best in deep, fertile and carbonate soils, of medium mechanical composition, which are not prone to crust formation. It also has very good results in slightly wetter soils that are well-aerated and fertile. Oilseed rape root requires more oxygen than the root of cereal crops. For proper growth and development of the plant, the main root of oilseed rape must have the opportunity to penetrate deep into the

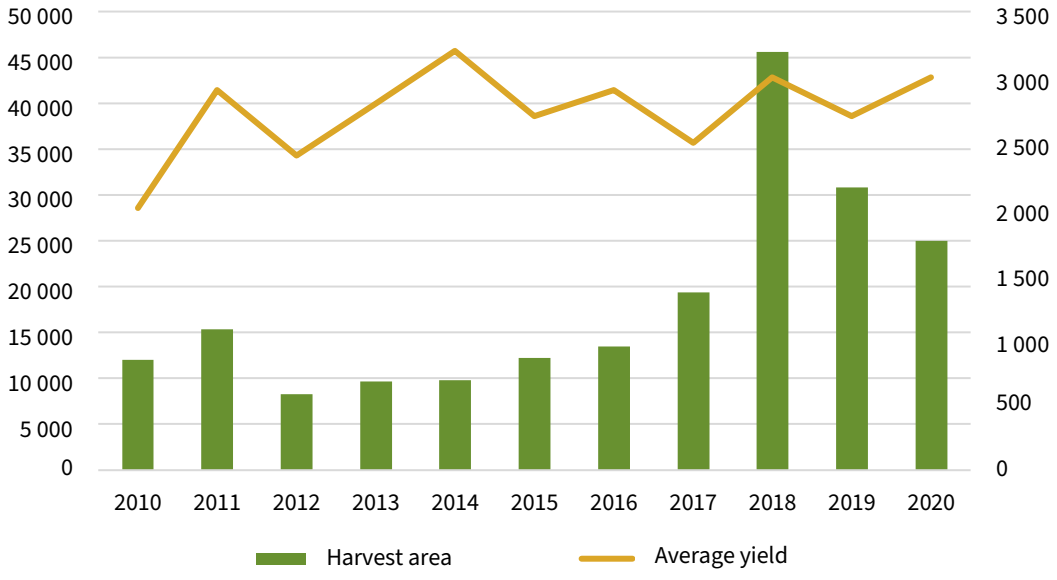


Figure 1: Harvest area (ha) and average yield (kg/ha) of oilseed rape in Serbia, 2010–2020
Source: Statistical Office of the Republic of Serbia.

soil; therefore, heavy, compacted soils and soils with an impermeable sub-ploughing layer are not suitable due to their poor drainage. In lighter soils of lower fertility, it gives more profitable yields than most other field crops and is often destined within the farm, for cultivation on lands of poorer quality. Its yield decreases significantly in low fertility soils. This decrease in yield is more pronounced when the production of oilseed rape is transferred from medium-fertile to low-fertile soil than when it is transferred from fertile to medium-fertile soil. Oilseed rape can be successfully grown in hilly and mountainous regions up to an altitude of 750 m, and it is quite tolerant to the wide range of pH values of the soil. It can be successfully grown in acidic (up to pH 5.5) and alkaline soils (up to pH 8.5), but it is best suited to neutral or slightly alkaline soils (pH 6.6–7.6).

Light

Oilseed rape is a long day plant. Serbia is located between the 42nd and 46th degrees of northern latitude and insolation is sufficient in all areas, i.e. light is not a limiting factor for growing winter and spring forms of oilseed rape.

Well-developed oilseed rape plant, before winter comes.

Temperature

The success of oilseed rape production is largely dependent on the temperature conditions during the vegetation period. The minimum temperature for germination and emergence is 3–5 °C, while the optimal temperature is 20–30 °C. By sowing, in early September, at temperatures of 14–17 °C and with optimal soil moisture, oilseed rape emerges in 4–6 days. The optimal temperature for autumn growth is 15 °C.

Growth of the above-ground plant parts and the root stops when the temperature drops below 5 °C and 2 °C, respectively, and then the plant enters the winter dormancy stage.

Oilseed rape flower.

Honey bee on a flower.

The degree of the plant development before winter dormancy is adjusted by the sowing time. Oilseed rape must reach the appropriate level of development and enter the generative stage before winter. The formation of flower primordia begins in November (by sowing in August) and lasts until mid-December (by sowing in September). The yield of oilseed rape significantly depends on the number of formed flowers. Like other winter field crops, oilseed rape must be gradually adapted to low temperatures during autumn in a process called “cold hardening”, i.e. increasing resistance to low temperatures. In order to complete cold hardening, it is important that air temperatures gradually drop during autumn and winter. At temperatures from 5 to 7 °C, during 14–20 days the first, “light”, stage of hardening occurs in which sugars accumulate in the cell, while at temperatures from -5 to -7 °C, during 5–7 days the second, “dark”, stage occurs in which the water content in the cell is reduced and the final resistance to low temperatures is achieved. Before the beginning of winter, the plants should have a fully developed rosette with 7–10 leaves, a root neck thicker

than 8 mm, stem height up to 1 cm, and the main root up to a depth of 10–15 cm. In this state, oilseed rape can withstand frosts down to -15 °C. With a snow cover about 2–6 cm thick, oilseed rape can withstand temperatures up to -25 °C. A well-prepared plant for the winter can regenerate even in the case of freezing of the growth point and epicotyl because new stems emerge from the buds of the hypocotyl, which give satisfactory yields.

Oilseed rape in fertile soil in the full flowering stage.

Oilseed rape in the seed filling stage.

With an average daily temperature higher than 7 °C, it takes about 40 days from the spring awakening of the vegetation to the beginning of flowering. Flowering usually begins in the second half of April when the average daily temperatures are between 11 and 14 °C. Temperatures have a great impact on the duration of the flowering period, but the duration does not significantly affect the yield of oilseed rape. It is much more important that as many buds as possible emerge at the same time early in the spring. The height and quality of the yield are largely determined by the temperatures from the flowering to ripening stage.

Water

Oilseed rape has high water requirements. The required annual amount of precipitation is 500–750 mm. It is most sensitive to drought from the stage of flower bud formation to the stage of flowering (intensive growth) and during the grain filling stage. In our semi-arid conditions, the lack of water in the sowing period is the critical point of production. Sowing in dry soil slows down germination and sprouting, does not allow plants to develop enough before winter, weakens their overwinters, and reduces their yield.

Oilseed rape seed.

Natural disasters and stress in oilseed rape

Climate change can significantly impact oilseed rape production. Extreme weather events, such as droughts, heavy precipitation and floods, have become more frequent due to climate change. Increases in temperature, droughts, and waterlogging cause stress on plants, as well as the appearance of new pests and diseases in our region, and require changes in oilseed rape production technologies. Crop yield is greatly influenced by complex interactions among plant, abiotic factors (climatic and soil conditions) and agricultural practices. Abiotic stress threatens not only the yield and its components but also the quality of seeds and the economic value of crops. Natural disasters that most threaten the production of oilseed rape are low temperatures, heavy rainfall and floods, stormy winds and hail, soil erosion, high temperatures, and drought. Their effects on oilseed rape are described below.

Low temperatures

Variable low temperatures cause alternating freezing and thawing of the soil which adversely affects oilseed rape. At high soil moisture, oilseed rape already freezes at -7 to -10 °C. If the plants are overdeveloped before winter, due to too early sowing, too dense sowing or high doses of nitrogen fertilisers, the growth point is located at a height of 10 cm or more. Such a crop cannot be protected from desiccation by lower snow cover, and often suffers from suffocation under too high snow cover. Late sown plants form a smaller number of leaves before winter and easily freeze, which causes them to poorly regenerate and to lag in growth during the spring. Oilseed rape can be damaged in the spring during early, short-term frost, especially if there is an excess of water in the soil.

Heavy precipitation

Heavy precipitation is increasingly occurring in the spring. If water is retained on the soil surface, as is the case with clayey, poorly permeable soils and in micro-depressions, there is no air in the soil and anaerobic conditions are created, which are unfavourable and prevent root

development and respiration. Heavy precipitation in the final stages of ripening and harvesting can also cause yield losses, primarily because it is impossible to enter the field with a combine due to the wet soil but also because, if the storm lasts, plants lie down, pods burst and matured seeds shed.

Frost on oilseed rape.

Floods

When an oilseed rape crop is flooded, the damage is mostly complete. Only a small number of plants survive, their health condition is bad and further production of the same crop does not make sense, i.e. no yield can be expected to cover the production cost. In case of floods in the autumn, it is best to re-sow a new oilseed rape crop on the same soil surface, if the agro-ecological and organisational conditions allow this and if the plants can develop enough to be ready for winter dormancy. In case of floods in the later part of the vegetation period, after drying and adequate preparation of soil for sowing, another plant species should be sown.

Stormy winds and hail

Stormy winds and hail break down and lodge the stems, destroy the leaf surface, damage and tear off the pods, and reduce the yield of oilseed rape. Damaged parts of plants are susceptible to attack by pathogens and pests, which further complicates production and reduces the yield and its quality.

Flood in a field sown with oilseed rape (location: Rimski šančevi).

Consequences of stormy wind and hail (location: Rimski šančevi).

Erosion

Erosion degrades the soil, mainly by removing its upper, fertile layers. The erosion occurs in the event of heavy precipitation, floods, stormy winds and hail. However, the soil erosion may also be a slow process of soil degradation that takes place almost imperceptibly.

High temperatures

The increase in the frequency and intensity of high temperatures has been noticeable in recent years. In the period from 1961 to 2015, average daily temperatures increased by 1.2 °C. Climate models predict further increases in temperature in Serbia by 2–4.3 °C (compared to the period from 1986 to 2005) as well as increases in stress, under the influence of high temperatures and drought, up to 50 percent by 2100. Consequences of stress caused by heat or high temperatures significantly depend on the amount of available water in the soil. There is a noticeable difference in the yield of oilseed rape between the years in which high temperatures and droughts occurred and the years with a temperate climate. High temperatures above 35 °C during the reproductive stage of oilseed rape can lead to significant damage of reproductive processes. Heat stress during the flowering and seed development stages negatively affects pollen development, egg fertilisation and embryo development. Also, the total surface area of the leaves decreases and the level of photosynthesis during flowering decreases. High temperatures adversely affect seed formation and development, oil synthesis, and accumulation, which reduces the final oil yield in extreme situations by more than 85 percent.

Drought

Moisture deficiency leads to poor germination and reduced productivity of oilseed rape. The lack of moisture in the soil during the optimal time for sowing, from 25 August to 20 September, makes it difficult to prepare the soil for sowing and, afterwards, the emergence of crops. Since, in the main regions of oilseed rape cultivation in our country, there is a very small percentage of areas with the irrigation system, drought has a great impact on the sowing. By sowing small,

dry oilseed rape seeds in soil that does not contain enough accessible moisture, they germinate and emerge with difficulty. With small amounts of precipitation, provocative emergence occurs, young plants dry out, and the crop has insufficient and uneven density.

Good agricultural practices and technologies to mitigate the impacts of natural disasters in oilseed rape production in Serbia

Oilseed rape production technology implies a series of measures (practices, techniques) that refer to: crop rotation, soil tillage, variety selection, sowing, intercropping, crop nutrition (fertilisation), weed, pathogen and pest control, irrigation/drainage, and harvesting. Below, good agricultural practices (GAPs) for winter oilseed rape production technology in ecological conditions of Serbia are described. These GAPs should provide for proper growth and development of plants and provide farmers with high yields and incomes from oilseed rape production. Properly developed plants are healthy and strong, they easier resist fluctuations in external factors, and they are less susceptible to stress. In this sense, the application of the listed GAPs is the basis to mitigate the impacts of natural disasters in the production of oilseed rape. The omission of any of these GAPs or a significant deviation from them represents a neglect of the needs of plants during their growth and development, which causes stress to plants and loss of yield.

Crop rotation

Crop rotation is a planned sequence of growing different crops on one plot. Crop rotation helps to preserve soil fertility, increase crop productivity and successfully control weeds, diseases and pests. Proper crop rotation can also mitigate the impact of drought.

Recommended practices and technologies:

1. Pay attention to the choice of forecrops. The best forecrops for oilseed rape are those that leave a lot of time for quality soil preparation, weed-free soil and enable good furrow cutting during basic tillage. The best forecrops are small grains, early potatoes, and early vegetables. Oilseed rape should not be grown after sunflower, mustard, soybean, pea and other legumes, clover or alfalfa because it is susceptible to diseases and insects that overwinter in the remains of these species.
2. Avoid continuous cultivation of oilseed rape (monoculture). In case of this or frequent return of oilseed rape to the same field, there is danger of increasing the number of insects and pathogens and increasing the difficulty of weed control, which leads to a decrease in seed yield.
3. If herbicides are used in production, check if there are any restrictions on their use in crop rotation.

Soil tillage

Proper tillage helps mitigate the impacts of heavy precipitation, floods and droughts. Tillage is the agricultural preparation of soil through manual or mechanical methods, such as turning, chopping and mixing. Tillage reduces soil compaction, improves soil structure and, thus, contributes to more efficient use of water and nutrients, protection against erosion, greater efficiency of applied herbicides, and increasing of crop competitiveness. Tillage includes conventional tillage (primary and secondary) and conservation tillage.

Recommended practices and technologies:

Conventional tillage

The tillage must create conditions for fast and uniform germination of relatively small seeds and good rooting in a short autumn period so that oilseed rape can build a strong leaf rosette before winter.

4. Immediately after the harvest, peel stubble by shallow ploughing or disc-harrow with a heavy disc-harrow to a depth of 12–15 cm. This measure brings the harvest residues into the soil, where they will be decomposed by micro-organisms and become nutrients for cultivated plants. It also stimulates weeds to germinate, destroys already emerged weeds and, thus, facilitates their control. Tillage disrupts the capillary system on the soil surface, thereby preventing moisture loss.
5. Do not burn crop residues. High temperatures and flames lead to the disturbance of soil flora and fauna in the upper layer of the soil from 20 to 25 cm, pollute the environment and damage the plants on the neighbouring plots. In addition, burning stubble is harmful to human health and often has tragic consequences for wildlife.
6. Perform primary tillage by ploughing with mouldboard or a chisel plough to a depth of 20–30 cm, no later than 3 weeks before sowing, so that the soil settles in a natural way and enables quality sowing. Oilseed rape is sensitive to shallow cultivated soil because it has a spindle-shaped, unbranched root that deeply penetrates the soil and does not form adventitious roots. A well-developed root system allows plants to receive moisture from the deep soil profile during droughts.
7. After ploughing, close the furrows as soon as possible and level the surface. This better preserves the existing moisture in the soil and enables better

seedbed preparation. Use different combinations of tools (disc harrow, harrower and roller), depending on the characteristics of the soil.

Soil preparation for sowing.

Seedbed preparation.

Secondary tillage (seedbed preparation)

Seedbed preparation should ensure good contact between the seeds and soil, i.e. fast and even germination and emergence.

8. Perform seedbed preparation with field cultivators, harrows, rollers, cultipackers, etc., in one or several passes, until a fine-grained structure of about 6 cm is created in the surface layer and, on the surface itself, smaller soil aggregates (up to 3 cm in diameter) that prevent the appearance of crusts. Seedbed preparation should destroy young weed plantlets and germinated weed seeds as well as level the soil, which is very important for uniform sowing depth and emergence of oilseed rape seeds.

Conservation tillage

9. Apply conservation tillage if soil characteristics allow. There are different systems of conservation tillage, such as reduced tillage, zone tillage, mulch tillage, zero tillage or direct sowing, with numerous variations, which are less frequently applied in Serbia but are of great importance in other countries with large areas under oilseed rape. Conservation tillage achieves energy savings, preserves soil moisture and increases microbiological activity.

Variety selection

As a result of intensive and long-term selection, there is a wide range of oilseed rape varieties intended for both conventional and organic production types. Numerous “double-zero” or 00-lines and hybrids (hereinafter: varieties), without erucic acid and with low glucosinolate content are available on the market. Varieties of type “00” provide oil suitable for human consumption, industrial processing and production of biofuels, and their meal, obtained after the oil is extracted from the seed, is suitable for domestic animals. The choice of variety is very important to mitigate the impacts of natural disasters. When choosing varieties, take those that are adapted to the agro-ecological conditions in the cultivation area, while at the same time giving high and stable yields of seeds and oil, so that they enable the producer to make a profit. Yield stability and quality as well as economic value of production largely depend on the choice of seed/variety to be grown in the field.

Diversity of oilseed rape varieties.

Recommended practices and technologies:

10. Follow the recommendations of agricultural extension services regarding the choice of good varieties adapted to ecological conditions in the production area. When choosing the variety, farmers should also follow their own experience and the experiences of oilseed rape producers in the region.

11. Choose varieties that are less responsive to variable autumn temperatures and do not pass from the rosette stage to stem growth before winter because this affects the reduced resistance to low temperatures.

12. Choose varieties with intensive growth in the spring and early and uniform flowering because this ensures that the plants have enough time to form and fill the seeds well before the appearance of high temperatures. Proper and timely passage of the plants through all phenophases enables the crop to realise its genetic potential for seed quality and yield and to be ready for harvest before the harvest of wheat. This is important for a more profitable use of machinery and other resources on the farm.

Oilseed rape breeding.

13. To minimise the effects of variation of agro-ecological factors, especially temperature and precipitation, grow drought-tolerant varieties. Also, in production of oilseed rape, pay attention to domestic varieties because they are accustomed to similar climatic conditions in which the production takes place.

14. In areas where stormy winds and hail occur, cultivate varieties that are resistant to lodging and seed pod cracking.

15. Diversify oilseed rape production by using varieties with different morphological, physiological and productive characteristics (plant height, number of branches, flowering time, number of pods, seed mass, ripening time). If a reduced value of one trait affects the yield, this allows other traits to compensate for its contribution to the yield, which ensures production stability.

Oilseed rape assortment.

Sowing

Sowing is a practice of key importance for the successful production of oilseed rape in Serbia. Oilseed rape is sown earlier than small grains because overwintering of oilseed rape is somewhat weaker. Unlike wheat, whose growth point during autumn and winter is below the soil surface, in oilseed rape it is above the soil surface; thus, it is more exposed to lower temperatures and there is a higher risk of freezing during winter. It is very important that oilseed rape in a short autumn period develop a rosette with 6–8 leaves that ensures the accumulation of sufficient nutrients in the thickened root crown because that allows for better overwintering and accelerates spring growth of plants.

Recommended practices and technologies:

16. Use only certified seeds.

17. Avoid sowing in freshly tilled soil. Sowing in such soil is difficult and of poor quality, which results in uneven emergence and uneven distribution of plants in the field, difficult plant protection, and poor stress tolerance.

18. Sow in the optimal time (25 August–20 September). Premature and late sowing have an adverse effect on seed yield. With premature sowing during the fall, an overgrown crop is developed in which the epicotyl of the stem elongates, and such plants overwinter poorly. The negative effect of late sowing is even more pronounced: the plants enter the winter underdeveloped, with little reserve of nutrients (soluble carbohydrates and phospholipids) in the stem and root, they freeze more easily, they regenerate more slowly in the spring, and they are late in growing, which results in a reduction in yield.

19. Determine the seeding rate for each variety using the following formula: Qs = (Np x M x 100) / (G x P), where: Qs = quantity of seeds (kg/ha); Np = recommended number of plants/m^2, M = mass of 1 000 seeds (g), G = germination rate (%), and P = seed purity (%). In the production of hybrid varieties, 500 000–550 000 seeds/ha are sown, and in the production of line varieties, 600 000–750 000 seeds/ha. Follow the instructions of seed companies and the recommendations of extension services. With lower crop density, plants are more prone to stronger branching, which is important as partial compensation for the insufficient number of plants per unit area. However, pronounced branching leads to uneven ripening and greater presence of weeds. Too dense sowing causes poorer development of plants before winter and greater susceptibility to freezing, lodging and disease infection.

20. Adjust the sowing depth to 1.5–2.5 cm because oilseed rape seed is very small (the weight of 1 000 seeds is 4–6 g).

21. Sow in rows with a 20–30 cm spacing. The most common space between rows is 25 cm. With subsequent cultivation, it is also possible to sow with a 50 cm spacing.

Oilseed rape seed.

22. Sow oilseed rape only when the soil has enough moisture. If soil dehydration occurs when the seedlings are 2–3 days old, they will not survive, especially because at that time of sowing the daily temperatures often exceed 30 °C for a continuous period of several days.
23. After sowing, if the soil is not too wet, roll the soil to establish good contact of the seeds with the soil and enable capillary movement of water. Thanks to this measure, the rooting of plants is better and the sprouting of plants is faster and more uniform.
24. Oilseed rape is sensitive to the appearance of structural crust, which can occur after heavy rains or irrigation before germination. Practices of maintaining good soil structure and application of lower irrigation rates reduce the development of soil crusts. If it is necessary to break a soil crust, apply a shallow, light tillage.

Intercropping

Intercropping is a production system of growing two or more crops side by side. In this way, solar energy, water and soil are better used. Intercropping enables greater stability and diversity of production, particularly in years with different extreme weather events that adversely affect agriculture.

Recommended practices and technologies:

25. In Serbia, farmers apply intercropping of oilseed rape with one or even two plant species, only in smaller areas. Oilseed rape is successfully combined with legumes. Combining oilseed rape with peas improves nitrogen intake and total crop seed yield and is often used in organic farming systems. There are two ways of intercropping: one is in alternating rows or strips of oilseed rape and another crop, and the other is sowing a mixture of seeds (mixed cropping).

Combined crops.

Crop nutrition (fertilisation)

Proper nutrition helps to mitigate the impacts of drought and low and high temperatures and contributes to better plant condition and resistance to pathogens and pests, which results in a high yield of good quality. Applying optimal doses of fertiliser at the right time reduces nutrient leaching during heavy precipitation. The most important nutrients for plants are nitrogen (N), phosphorus (P) and potassium (K). Fertilisation helps crops to be more competitive in relation to weeds, not only for nutrients but also for all other resources.

Recommended practices and technologies:

26. Perform soil analysis and determine the content of N, P and K before fertilisation and tillage. The results of the analysis represent the basis for calculating the amount of nutrients needed by plants to obtain the target yield. Approximate amounts of nutrients for oilseed rape yield of 3 000 kg/ha are: 210 kg/ha of nitrogen (N), 75 kg/ha of phosphorus (P_2O_5) and 300 kg/ha of potassium (K_2O).
27. Compensate for deficiency of essential microelements for plant growth in soil by adding fertilisers of special formulations into the soil or by treating the crops with foliar fertilisers.
28. Apply the total amount of phosphorus and potassium and one-third of nitrogen before sowing and apply the remaining nitrogen in the spring.
29. Increase the dose of nitrogen if oilseed rape is produced under irrigation conditions. Carefully increase the dose of N because excessive fertilisation with N can lead to overgrowth of crop and increase its sensitivity to low temperatures and lodging.
30. Oilseed rape's need for nitrogen is highest during spring growth, about 100 kg/ha. Apply nitrogen when plants come out of winter, by the end of February. When using a larger amount of N in the nutrition, for example, 160 kg, it is better to split this amount into 2 parts: apply the first part (80 kg) as soon as the vegetation growth begins and apply the remaining part (80 kg) 2–3 weeks later. Fertilisation divided into two doses enables fast recovery of the plant after winter stimulates their initial growth, affects better N use efficiency and prevents N leaching. Foliar application of one part of nitrogen fertiliser (up to 40 kg/ha) in combination with microelements at the end of flowering can significantly increase the yield.
31. For acid soils (with pH less than 5.5–6.0), perform calcification and other measures to improve pH.
32. Oilseed rape reacts well to organic fertilisers, but due to the short period of time between forecrop harvesting and oilseed rape sowing, they are supplied during the cultivation of the previous crop. It is desirable to apply composted (burned) manure, i.e. organic fertilisers, if available, once every four years, or more if often under irrigation conditions.

Weed, pathogen, and pest control

Control of weeds, pathogens and pests is especially important as a practice because only completely healthy plants can adequately resist unfavourable environmental conditions. Weeds compete with cultivated plants for space, light, water, and nutrients. Pathogens and pests are destructive organisms that attack crops. It is important for agricultural producers to develop an adequate strategy for their control.

Recommended practices and technologies:

33. Develop an integrated management control of weeds, pathogens and pests by combining mechanical, agro-technical (crop rotation, tillage, crop density), biological, and chemical measures and practices. This must be an ecosystem-based strategy that focuses on long-term prevention. When applying plant protection products, follow the manufacturer's instructions and the recommendations of the advisers and comply with the preharvest interval (PHI), the amount of time that must lapse after a pesticide application before the crop is harvested.

Weed control

34. Control of weeds in oilseed rape must be effective. The presence of weeds in the crop prevents the normal growth of cultivated plants, which weakens their resistance to low temperatures during the winter period and slows down their development in the spring. The presence of weeds in the crop can reduce combine efficiency, increase the seed moisture and delay harvest. If the seeds of oilseed rape are contaminated with the weed seeds during harvest, the quality of the oil will significantly decrease. Primary tillage and seedbed preparation are of great importance for successful and sustainable weed control. Quality implementation of these practices enables the crop to evenly emerge without the presence of weeds and the effective action of soil herbicides.

Different weed species of oilseed rape.

35. Pre-emergence treatments of herbicides in oilseed rape are generally based on metazachlor, which may be tank mixed or used as a co-formulated product with clomazone, to improve control of broad leaf weeds. Other co-formulations with clopyralid, picloram and aminopyralid enhance the spectrum of weeds controlled when used post-emergence, in stage with 2–4 leaves (15 cm height) of oilseed rape or 2–6 leaves of weeds.

36. Control self-sprouted wheat and barley with herbicide quizalofop-p-ethyl when the oilseed rape has 2–4 leaves. Control annual and perennial grass weed with fluazifop-p-butyl when they have 3–5 leaves.

37. Oilseed rape belongs to the cabbage family (*Brassicaceae*). Against weed species from this family, of which the most common is field mustard (*Sinapis arvensis* L.), there is no appropriate herbicide. Control these weeds with chemical measures in the forecrops and agro-technical practices after removing the forecrops. Do not grow oilseed rape in fields where the population of weed species from the cabbage family is extremely large.

Field mustard in rapeseed crop during the winter.

Pathogen control

38. Many parasitic micro-organisms (fungi, bacteria, viruses) have been noticed on oilseed rape. The most common and harmful parasites are phytopathogenic fungi, such as: *Leptosphaeria maculans* (stem canker or blackleg), *Phoma lingam* (dry rot), *Sclerotinia sclerotiorum* (cottony rot), and *Alternaria brassicae* (dark spot).

Leptosphaeria maculans on an oilseed rape leaf.

Phoma on the stem.

The leaves of a plant infected with the virus.

Adhere to integral protection measures (healthy seeds, cultivation of tolerant varieties, crop rotation, ploughing of crop residues) to reduce the presence of pathogens. If a stronger pathogen attack is observed on plants during the fall and spring, it is necessary to apply chemical treatments. Certain fungicides that are applied in the fall also act as growth retardants and help to reduce further longitudinal plant growth in overgrown crops without lowering plant productivity.

39. With the spread of areas under oilseed rape, viruses of this plant species are gaining increasing economic importance by reducing seed yield and oil content. Oilseed rape plants infected with turnip yellow virus (TuYV) show a series of symptoms that usually go unnoticed or are explained by stress and lack of nutrients. The plants infected with TuYV exhibit a variety of symptoms, some of which are reddening of leaf margins, interveinal yellowing or reddening, leaf curling, leaf rolling and brittleness. Infected plants remain dwarf and have short roots. Preventive measures, such as the control of aphids, along with practices and technologies that enable rapid crop development and protect plants against biotic and abiotic stress, including crop rotation and cultivation of resistant varieties, are currently the only means of protection.

Sclerotinia sclerotiorum on an oilseed rape stem.

Pest control

40. Insects on oilseed rape reduce yields in agro-ecological conditions of Serbia by an average of 15–20 percent. Only use insecticides if monitoring indicates that they are necessary. Using integrated pest management (IPM) means creating conditions that are unfavourable for the pest, protecting the environment and increasing the profitability of oilseed rape cultivation. In IPM, great importance is placed on the application of agro-technical practices that reduce pest establishment and dispersal, cultivation of resistant or tolerant varieties, and use of predators – natural enemies of pests. All measures that enable oilseed rape plants to be healthy and go through the developmental stages in optimal conditions contribute to the reduction of damage. Reduce the number of harmful insects by destroying weeds from the cabbage family, as well as by irrigation. It is important to create conditions that will enable the newly sprouted oilseed rape plants to quickly grow and develop so that the time period when insects damage the plant is shortened.

41. In the autumn, the cabbage-stem flea beetle (*Psylliodes chrysocephala*), the turnip sawfly (*Athalia rosae*) and flea beetles of the genus *Phyllotreta* are among the most harmful species of insects in the rapeseed crop. The adult insect of the cabbage stem flea beetle is up to 4.5 mm long, greenish or bluish-black, with a metallic reflection and red on part of his head. The larva is dirty white with a brown head, 1.5 mm long when hatched and up to 8 mm at the end of development, with clearly expressed 3 pairs of legs on the chest.

    The turnip sawfly imago has a body length of 6–8 mm. The back of the body is yellow or yellow-orange, while the head and sides of the chest are black. The body of larva is wrinkled, sometimes with spots, and is 16–18 mm long. Newly hatched larvae are light green to grey. As they grow, their colour changes and becomes darker, dark green to black on the back and grey on the abdomen.

    Flea beetles are small insects with a body length of 2–3.5 mm. They jump and fly well. They are bright

black, dark blue or dark green in colour; some species have yellow longitudinal stripes on the covers. These insects can cause significant damage after oilseed rape emergence in the cotyledon stage. Due to the ban on the treatment of seeds with insecticides from the group of neonicotinoids, protection against these insects is significantly hindered. Foliar insecticides are most commonly used in rapeseed production. From this group, insecticides with the active ingredients deltamethrin, lambda-cyhalothrin, and alpha-cypermethrin are registered for use in Serbia. In our agro-ecological conditions, one to two treatments are sufficient.

Cabbage stem flea beetle.

Turnip sawfly larva.

Fleas on an oilseed rape leaf.

Control flea beetles when it is established that about five percent of the leaf mass has been damaged, and/or when there is present, on average, one turnip sawfly larva on two plants. Neglecting pest control can lead to serious losses in the stage when cotyledons and the first true leaf emerge, such that it is necessary to re-sow the crop. Leaf area losses caused by pests in the advanced development stages (5–8 permanent leaves) affect reduction of photosynthesis, higher sensitivity to low temperatures and poorer overwintering of plants.

42. In the autumn, various species of rodents (hamsters, voles, field mice, etc.) can also cause damage in rapeseed crop. Mild winters and alternating rain and warm weather conditions during spring can lead to a calamity (increased numbers) of rodents. Regularly monitor rodents in the crop from sowing to early spring. Placing baits into rodent holes is the most common protection measure, with mandatory backfilling of holes to prevent potential effects on natural rodent predators and other non-target species.

Damages caused by rodents.

43. In the second (spring) part of the vegetation period of oilseed rape, crop damage is caused by insects: cabbage stem weevil (*Ceutorhynchus pallidactylus*), rape stem weevil (*Ceutorhynchus napi*), common pollen beetle (*Brassicogethes aeneus*, previously known as *Meligethes aeneus*) and blossom beetle (*Tropinota hirta*).

Larva of cabbage stem weevil in stem (left)
Cabbage stem weevil. (right)

The adult insect of the rape stem weevil is ashy-grey in colour and 3–4 mm long. Its body is covered with short, grey hair. The larvae are legless, curved, whitish, and up to 8 mm long. The head of the larva is dark in the first two stages, and in the last, third stage it is yellowish. The cabbage stem weevil is similar to the rape stem weevil: ashy-grey, with a small white spot at the base of its elytra. It is 2.5–3.5 mm long. The larvae are whitish, legless, with a yellowish-white head, and about 3–5 mm long. Cabbage and rape stem weevils lay eggs in early spring on the leaf petioles. After the eggs hatch, the larvae burrow first into the leaf petioles, and then into the stem, causing direct and indirect damage. Control is necessary if an average of one stem weevil per five oilseed rape plants is found.

The common pollen beetle is economically the most significant pest of oilseed rape. It occurs before flowering and damages the flower and flower buds. The body of an adult insect is 2–2.5 mm long, dark blue or dark green with a metallic reflection. The larva is yellowish-white and sparsely covered with hairs. There are 2–3 dark spots on each segment of its back. The larva grows to a length of 4 mm. In oilseed rape, apply insecticides to control the common pollen beetle in the buttonisation phase when an average of 1–2 adults per bud is found. To suppress stem weevils and common pollen beetles, insecticides with the active ingredients deltamethrin, lambda-cyhalothrin, alpha-cypermethrin, cypermethrin and chlorpyrifos are registered for use in Serbia.

Blossom beetles occur during the flowering of oilseed rape, damaging the flowers. Adult specimens are 8–12 mm long, black in colour with irregular white spots on the elytra. The body is covered by numerous thick, grey hairs and bristles. Due to the time of appearance and the presence of numerous pollinators, chemical treatment is not allowed. Damage can be mitigated by sowing larger plots, denser sowing along the perimeter of the plots, and mass trapping of insects in plastic containers filled with water into which candies or sweet juice can be added.

Common pollen beetle.

Blossom beetle.

Irrigation

Irrigation helps mitigate the impacts of high temperatures and soil and air drought. Irrigation ensures that the plants' optimal water needs are met, activates soil micro-organisms and nutrient reserves, and contributes to better utilisation of fertilisers.

Recommended practices and technologies:

44. To achieve a high yield of oilseed rape with appropriate quality, it is necessary for the plants to be optimally supplied with water. Any period in which a plant suffers from a lack of water reflects on both yield and seed quality and can be considered critical. That is why it is important to water the crop when there is a need for it, not only in the so-called "critical stages". For oilseed rape plants, the critical periods in the need for water are germination and emergence, intensive growth, seed formation, and seed filling. It is best to irrigate in accordance with the water balance, i.e. to compensate the plants for water consumed by evapotranspiration.
45. When watering, the irrigation rate must be appropriate. In drought conditions, to prepare the soil for sowing and activate the applied herbicides, the plot can be irrigated before sowing. After sowing, do not water oilseed rape at once with high irrigation rates because this can cause soil crust formation at high temperatures. If crust appears, correctively water with lower norms.

Oilseed rape irrigation.

Drainage

Drainage primarily contributes to mitigating the impacts of heavy precipitation and flooding. Drainage is a measure of removing excess water from the soil surface and from the root zone, which aims to improve the soil structure and enable the roots to be better aerated.

Recommended practices and technologies:

46. Regularly maintain drainage canals and clean them of weeds and waste to provide unobstructed runoff of surface water and to prevent floods.
47. Before ploughing hard soil that retains water on the surface in the spring, conduct vertical tillage and break the plough sole by subsoilers.

Harvesting

Timely and correct harvesting helps avoid the negative impacts of heavy precipitation, stormy winds and hail, high temperatures, and drought. The harvest is one of the most important events in agricultural production. Choosing the right time for harvest is very important because the amount of yield depends on it. If the harvest is not done with properly prepared machinery or the harvest is delayed, significant yield losses can occur due to the opening of the pods and the shedding of seeds.

Oilseed rape before harvest.

Recommended practices and technologies:

48. Harvest at technological maturity, when the crop is yellowish brown, the leaves are mostly dried, the pods on the side branches are mostly brown, and on the main axis they are grey-brown. The seeds are mostly brown and hard.

Oilseed rape harvest.

49. Harvest with grain harvesters, when the moisture in the grain falls below 15 percent. Make appropriate adaptations to combines that will harvest oilseed rape. Highest yield losses occur on the harvester header due to the impact of the reel. Set the reel to optimum speed or remove its steel fingers. It is preferable to use a lateral vertical passage divider or, even better, a vertical scythe as a passage divider. Minimal losses are realised at the position C of the reel (maximum back) and the kinematic coefficient of 0.85, i.e. when the rotational speed of the reel is identical to the forward speed of the combine. It is recommended to stretch the cutterbar table to collect as many seeds as possible. Set the speed of the threshing drum as slow as possible – below 500 rpm – and the sieves should be 3.5–5.0 mm in diameter. Fully open the "Peterson" sieve and fully extend the extension. Completely open a combine concave and regulate the strength of the wind depending on the humidity of the crop.

Oilseed rape harvest.

50. If the combine does not have either a vertical scythe or a divider, it is desirable to harvest in the morning or late in the evening when the appearance of dew and higher humidity reduces the risk of seed shedding.
51. After harvest, cool the seeds as soon as possible if the humidity is low, and if the humidity is high, dry the seeds. Store the seeds with a maximum of 8 percent moisture, and most often at the so-called "processing moisture" of 7 percent.

Crop insurance

52. Crop insurance in agriculture is the management tool based on risk-sharing strategy. In the case of oilseed rape crops, the seed yield is insured because that is the purpose of cultivation. Yield insurance covers yield losses due to the impact of different natural disasters. In yield insurance schemes, payoffs are triggered when yield falls below a certain predetermined level, which is usually based on a multi-year average yield. Crop insurance is encouraged through various subsidies and funds by the state and local governments. Agricultural advisers are available to farmers for education and assistance in crop insurance.

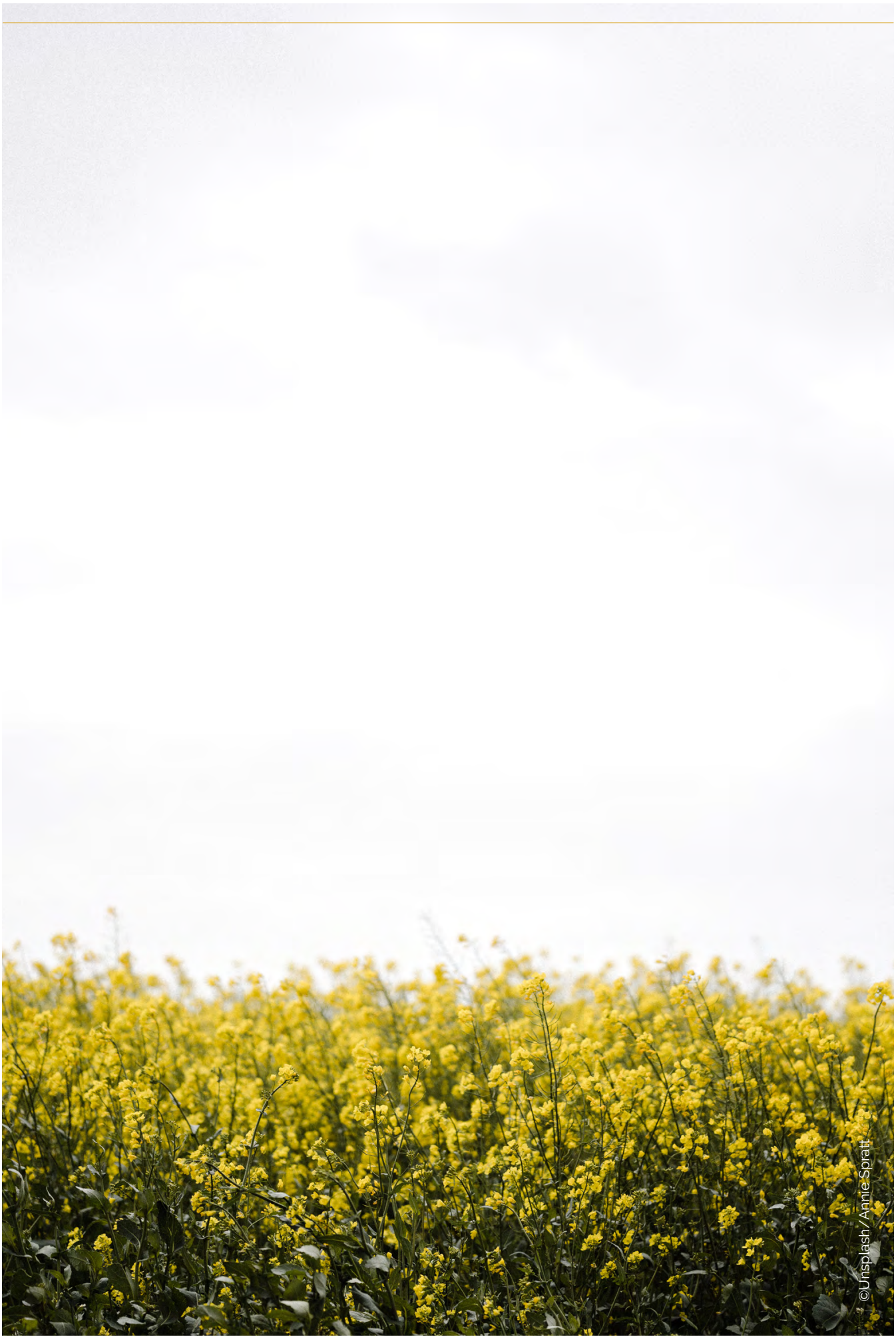
Summary

Oilseed rape is primarily known as an industrial plant. Its seed is an important source of oil and proteins for nutritional and non-edible uses. After the extraction of oil from oilseed rape seed, the meal (cake), rich in proteins, fibers, antioxidants, vitamins and minerals, which is suitable for feeding domestic animals, remains.

Areas under oilseed rape in Serbia have increased in the last decade. Over this period, the average yield of oilseed rape seed in Serbia was about 2.7 t/ha but varied depending on agro-ecological conditions. Climatic conditions in Serbia are suitable for oilseed rape production, but the occurrence of natural disasters (drought, floods, stormy winds and hail) leads to a decline in yield and seed quality.

For farmers, it is extremely important to choose the right variety of oilseed rape to mitigate the effects of natural disasters because each variety has specific advantages that can make it suitable for certain growing conditions. Farmers in Serbia can choose many high-yielding varieties created in our agro-ecological conditions. Likewise, a system of measures that includes the best crop rotation plan (oilseed rape fits well with winter cereals as a forecrop), basic tillage (to a depth of 20–30 cm), sowing (of certified seed, in the period from 25 August to 20 September), plant nutrition (total amount of nitrogen fertilisers divided into several doses), control of weeds, pests and diseases (by combining preventive measures, especially agro-technical practices such as crop rotation, tillage, and crop density), setting up of irrigation and drainage systems, as well as the timely harvest (when the seed contains less than 15 percent moisture) provides favourable conditions for the proper development of oilseed rape crops. This is the basis for mitigating the impacts of natural disasters and achieving high and stable yields. Neglecting these basic requirements of oilseed rape technology or reducing certain measures inevitably leads to yield losses. Also, farmers are recommended to consider the possibility of introducing agricultural technologies such as conservation tillage and intercropping that are successfully applied in the world but still are not present in larger areas in Serbia. Finally, one of the measures to mitigate the impacts of natural disasters, based on a risk-sharing strategy, is crop insurance. With the continuous education of producers and further improvement of the assortment, technology and machinery, it is realistic to expect an increase in the area under oilseed rape in Serbia and greater production safety under the conditions of climate change.

For education and assistance in the application of the listed agricultural practices and technologies, farmers can contact the Ministry of Agriculture, Forestry and Water Management, advisory services, and other addresses listed below.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Contact

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Zrenjanin	Petra Drapšina 15, 23100 Zrenjanin
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