

CHAPTER 1. AGROBIOLOGICAL POTENTIAL OF OILSEED RADISH

1.1. Origin, range and introduction of oilseed radish

Oil radish is an older crop than sowing radish. It was introduced into culture primarily as an oilseed plant. That is why the first stages of its study were aimed at assessing its manufacturability as a source of valuable oil, which is not inferior to mustard oil and is easily hydrogenated. The cake obtained in the process of seed processing was an effective component in cattle feeding.

Oil radish, as well as winter rape and rape, is considered one of the oldest species on earth. However, its widespread introduction into culture continues to this day. The reasons for its limited distribution are insufficient awareness of cultivation technology and the lack of industrial seed processing. Under the planned system of management, this crop was not included in state plans, administrative institutions were not interested in it, and farmers did not report on the condition of their crops. At the same time, the area under this crop grew year after year abroad. The growth of this crop in the period 2005-2024 is due not only to its fodder value, but also to the possibility of using the oil obtained from its processing for the production of alternative biofuels (Tsytsiura, 2011).

The genus *Raphanus* L. (radish) is small in number of species. According to Ilyinska (2008), there are 1–2 or 8–10 species, including both wild and introduced plants that are widely used as vegetables. All presented forms are diploid, except for artificially produced tetraploid forms. The primary area of the genus is attributed to the Ancient Mediterranean (Mediterranean center of origin of cultivated plants) with traces of origin from the West Asian center, and over the period of several centuries the genus has spread significantly across different continents of the world (Figs. 1–2). The systematics of the species is still controversial and ambiguous. It is complicated by the ability to cross-pollinate between different branches of taxa with the formation of short-lived intermediate forms.

In the flora of Ukraine, the genus *Raphanus* is represented by several species, including the wild *R. odessanus* (Andr.) Sprengl., *R. raphanistrum* L.,

and *R. candidus* Worosch. And cultivated *R. sativus*. The origin and scope of phylogeny of these species is also a controversial issue, given the possible intraspecific hybridization of oil and seed radish (Ovcharenko, 2006) and other genetic recombinations (Pistrick, 1987).

More recently, *R. acanthiformis* J. M. Morel ex L. Sisley (Japanese radish – daikon) and *R. chinensis* Miller (Chinese radish) have been cultivated in Ukraine. Today, oil radish (*Raphanus sativus* L. var. *oleiformis* Pers.) is defined as a variety of sowing radish (*Raphanus sativus* L.), genus *Raphanus* L., under the division II of *Raphanusae* DC., division 5 of *Brassicaceae* Hayek and belongs to the family *Brassicaceae*, order *Capparidales*, class *Dicjtyledaneae*. In recent publications, it is included in the group of varieties *Convar. oleiferus* L. – a group of varieties of oil radish with the following characteristics: annual plants, do not form a root crop, are grown for oil production from seeds and for fodder, vegetative and generative organs are similar to root forms.

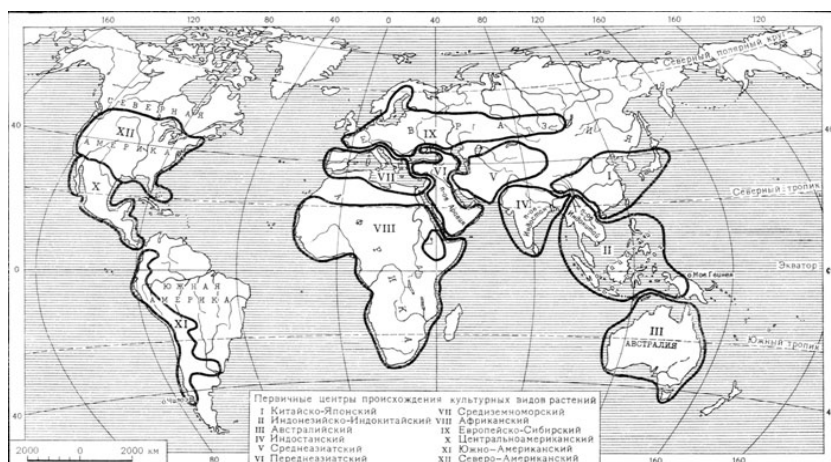


Figure 1.1 – Primary centers of origin of cultivated plants (current view) 1. Sino-Japanese; II Indonesian-Indochinese; III Australian; IV Hindustan; V Central Asian; VI West Asian; VII Mediterranean; VIII African; IX European-Siberian; X Central American; XI South American; XII North American (Centers of Origin of Cultivated Plants, 2024)

Detailed description of the *Raphanus* tribes (given in the original interpretation of the description by Swaamy, 2023):

- *R. sativus* (cultivated radish)
- *R. raphanistrum* (Wild Radish, or Jointed podded Charlock), a weed among barley, in Sweden. It is bristly, and has rather large, straw- coloured flowers.
- *R. sibiricus*, or Siberian Radish, has cylindrical pods.
- *R. caudatus*, the Java, or Rat's Tail Radish, a native of China, furnishes long, edible pods, purple or violet in colour. Type: Annual. They should be used half-grown. The root of this species is not used.
- *R. maritimus* (Maritime wild radish) an indigenous, seaside variety. A large, straggling plant, often more than 1m in height, covered in a cloud of pale yellow flowers in May and June. hard pod with a beaded appearance due to constrictions between each seed. Leaves are toothed and pinnate, and covered in coarse bristles

– *R. eruroides*, of Italy, has pods with a beak of their own length, and a simple, biennial root, scarcely thicker than the stem.

– *R. tenellus*, another native of Siberia, flowers in Britain in June and July, having awl-shaped, jointed, two-celled, smooth pods. The leaves are oblanceolate to elliptic-oblong, with sinuous or coarsely-toothed leaf edges.

According to Swaamy (2023) the cultivated radishes have several wild relatives such as *R. raphanistrum* and its subspecies viz, *R. raphanistrum* subsp. *Landra* (Moretti ex DC.) Bonnier & Layens, *R. raphanistrum* subsp. *maritimus* (Sm.) Thell., *R. raphanistrum* subsp. *microcarpus* (Lange) Thell., *R. raphanistrum* subsp. *raphanistrum*, *R. raphanistrum* subsp. *rostratus* (DC.) Thell., and *R. confusus* (Greuter & Burdet) Al-Shehbaz & Warwick. Sometimes these related species are considered as one species complex named *R. raphanistrum*, with the different taxa classified as subspecies. *R. sativus* crosses freely with the related wild species. *R. sativus* is also closely related to several Brassica species and to *Sinapis arvensis* (charlock), with which it has also been successfully crossed (CABI, 2019; CABI, 2022; NPT, 2022).

Botanical Varieties of Radish (WIKI, 2022):

– *Raphanus acanthiformis* M. Morel ex Sisley (Mansf) -> *Raphanus sativus* L. (Longipinnatus Group)

– *Raphanus caudatus* L. (GRIN) (NOPD) -> *Raphanus sativus* L. (Caudatus Group)

SCIENTIFIC MONOGRAPH

- *Raphanus caudatus* L. f. (Mansf) -> *Raphanus sativus* L. (Caudatus Group)
- *Raphanus chinensis* Mill. (Mansf) (NOPD) -> *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD)
- *Raphanus indicus* Sinskaya -> *Raphanus sativus* L. (Caudatus Group)
- *Raphanus macropodus* H.Lév. (NOPD)
- *Raphanus monnetii* H.Lév. (NOPD)
- *Raphanus niger* Mill. (NOPD) -> *Raphanus sativus* L. var. *niger* J. Kern. (Mansf) (GRIN)
- *Raphanus oleifer* hort. ex Steud. (NOPD) -> *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD)
- *Raphanus officinalis* Crantz (NOPD)
- *Raphanus orbicularis* Mill. (NOPD)
- *Raphanus radícula* Pers. (NOPD) -> *Raphanus sativus* L. (Radicula Group)
- *Raphanus radícula* (Pers.) Alef. (Mansf) -> *Raphanus sativus* L. (Radicula Group)
- *Raphanus raphanistroides* (Makino) Nakai (NOPD) (Mansf)
- *Raphanus raphanistrum* L. (GRIN)
- *Raphanus raphanistrum* L. subsp. *caudatus* (L.) Thell. (NOPD) -> *Raphanus sativus* L. (Caudatus Group)
- *Raphanus raphanistrum* L. subsp. *caudatus* (L. f.) Thell. (Mansf) -> *Raphanus sativus* L. (Caudatus Group)
- *Raphanus raphanistrum* L. subsp. *sativus* (L.) Domin (NOPD) -> *Raphanus sativus* L. subsp. *sativus*
- *Raphanus raphanistrum* L. subsp. *sativus* (L.) Schmalh. -> *Raphanus sativus* L. subsp. *sativus*
- *Raphanus raphanistrum* L. var. *niger* (Mill.) P. Fourn. (NOPD) -> *Raphanus sativus* L. var. *niger* J. Kern. (Mansf) (GRIN)
- *Raphanus raphanistrum* L. var. *radícula* (Pers.) P. Fourn. (NOPD) -> *Raphanus sativus* L. (Radicula Group)
- *Raphanus raphanistrum* L. var. *sativus* (L.) Beck (NOPD)
- *Raphanus rotundus* Mill. (NOPD) -> *Raphanus sativus* L. (Radicula Group)
- *Raphanus sativus* L. (GRIN)
- *Raphanus sativus* L. (Caudatus Group) (MMPND)

- *Raphanus sativus* L. (Chinensis Group) (MMPND)
- *Raphanus sativus* L. (Fodder Radish Group) -> *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD) A
- *Raphanus sativus* L. (Hortensis Group) -> *Raphanus sativus* L. (Radicula Group) (MMPND)
- *Raphanus sativus* L. (Japonicus Group) -> *Raphanus sativus* L. (Longipinnatus Group) (MMPND)
- *Raphanus sativus* L. (Longipinnatus Group) (MMPND)
- *Raphanus sativus* L. (Mougri Group) -> *Raphanus sativus* L. (Caudatus Group) (MMPND)
- *Raphanus sativus* L. (Oleiformis Group)
- *Raphanus sativus* L. (Radicula Group) (MMPND)
- *Raphanus sativus* L. subsp. *acanthiformis* (Blanch.) A. K. Stankevich -> *Raphanus sativus* L. (Longipinnatus Group) (MMPND)
- *Raphanus sativus* L. subsp. *acanthiformis* (Morel) A. K. Stankevich -> *Raphanus sativus* L. (Longipinnatus Group) (MMPND)
- *Raphanus sativus* L. subsp. *acanthiformis* (M. Morel ex Sisley) Stankev. (Mansf) -> *Raphanus sativus* L. (Longipinnatus Group)
- *Raphanus sativus* L. subsp. *esculentus* (Metzg.) Alef. -> *Raphanus sativus* L. (Radicula Group)
- *Raphanus sativus* L. subsp. *oleiferus* (Stokes) Metzg. (Mansf) (NOPD) -> *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD) A
- *Raphanus sativus* L. subsp. *raphanistroides* (Makino) Sazon. (Mansf) -> *Raphanus raphanistroides* (Makino) Nakai (NOPD) (Mansf)
- *Raphanus sativus* L. subsp. *sativus*
- *Raphanus sativus* L. subsp. *sativus* convar. *radicula* (Pers.) Sazon. (Mansf) -> *Raphanus sativus* L. (Radicula Group)
- *Raphanus sativus* L. subsp. *sativus* convar. *sativus* (Alef.) Sazon. (Mansf) -> *Raphanus sativus* L. subsp. *sativus*
- *Raphanus sativus* L. subsp. *sinensis* L.V. Sazonova & A. K. Stankevich -> *Raphanus sativus* L. (Chinensis Group)
- *Raphanus sativus* L. subsp. *sinensis* Sazon. & Stankev. (NOPD) -> *Raphanus sativus* L. (Chinensis Group)
- *Raphanus sativus* L. subsp. *sinensis* Sazon. & Stankev. convar. *lobo* Sazon. (Mansf) -> *Raphanus sativus* L. (Chinensis Group)

- *Raphanus sativus* L. subsp. *sinensis* Sazon. & Stankev. convar. *oleiferus* (Stokes) Sazon. & Stankev. -> *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD) A
- *Raphanus sativus* L. subsp. *sinensis* Sazon. & Stankev. convar. *sinensis* Sazon. (Mansf) -> *Raphanus sativus* L. (Chinensis Group)
- *Raphanus sativus* L. var. *acanthiformis* Makino -> *Raphanus sativus* L. (Longipinnatus Group)
- *Raphanus sativus* L. var. *acanthiformis* Makino fo. *raphanistroides* Makino -> *Raphanus raphanistroides* (Makino) Nakai (NOPD) (Mansf)
- *Raphanus sativus* L. var. *campestris* hort.
- *Raphanus sativus* L. var. *caudatus* Alef. -> *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD) A
- *Raphanus sativus* L. var. *caudatus* (L.) L.H. Bailey (NOPD) (GRIN) A -> *Raphanus sativus* L. (Caudatus Group)
- *Raphanus sativus* L. var. *caudatus* (L.) Vilmorin -> *Raphanus sativus* L. (Caudatus Group) ?
- *Raphanus sativus* L. var. *caudatus* (L. f.) Vilmorin (Mansf) -> *Raphanus sativus* L. (Caudatus Group) ?
- *Raphanus sativus* L. var. *chinensis* Gall. -> *Raphanus sativus* L. (Chinensis Group)
- *Raphanus sativus* L. var. *chinensis* (Mill.) Alef. (NOPD) -> *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD) A
- *Raphanus sativus* L. var. *hortensis* Baker -> *Raphanus sativus* L. subsp. *sativus*
- *Raphanus sativus* L. var. *hortensis* Baker f. *acanthiformis* Makino -> *Raphanus sativus* L. (Longipinnatus Group)
- *Raphanus sativus* L. var. *hortensis* Baker f. *raphanistroides* Makino -> *Raphanus raphanistroides* (Makino) Nakai (NOPD) (Mansf)
- *Raphanus sativus* L. var. *longipinnatus* L.H. Bailey (GRIN) (NOPD) -> *Raphanus sativus* L. (Longipinnatus Group)
- *Raphanus sativus* L. var. *minor* J. Kern. (Mansf) (NOPD)
- *Raphanus sativus* L. var. *mougri* Helm. (NOPD) (Mansf) -> *Raphanus sativus* L. (Caudatus Group) ?
- *Raphanus sativus* L. var. *niger* (Miller) Pers. -> *Raphanus sativus* L. var. *niger* J. Kern. A
- *Raphanus sativus* L. var. *niger* (Miller) S. Kerner -> *Raphanus sativus* L. var. *niger* J. Kern. A

- *Raphanus sativus* L. var. *niger* (Mill.) J. Kern. (NOPD) -> *Raphanus sativus* L. var. *niger* J. Kern. (Mansf) (GRIN)
- *Raphanus sativus* L. var. *niger* J. Kern. (Mansf) (GRIN)
- *Raphanus sativus* L. var. *oblongus* DC. (NOPD)
- *Raphanus sativus* L. var. *oleiferus* Stokes (GRIN) (NOPD) -> *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD)
- *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD) A
- *Raphanus sativus* L. var. *radicula* Pers. (Mansf) (NOPD) -> *Raphanus sativus* L. (Radicula Group)
- *Raphanus sativus* L. var. *raphanistroides* (Makino) Makino (NOPD) -> *Raphanus raphanistroides* (Makino) Nakai (NOPD) (Mansf)
- *Raphanus sativus* L. var. *rotundus* (Mill.) DC. (NOPD) -> *Raphanus sativus* L. (Radicula Group)
- *Raphanus sativus* L. var. *sylvestris* Koch (NOPD) -> *Raphanus raphanistrum* L.
- *Raphanus sativus* L. var. *sativus* (GRIN) -> *Raphanus sativus* L. subsp. *sativus*
- *Raphanus sativus* L. convar. *caudatus* (L. f.) Pistrick (Mansf) -> *Raphanus sativus* L. (Caudatus Group) ?
- *Raphanus sativus* L. convar. *oleifer* (Stokes) Alef. (Mansf) -> *Raphanus sativus* L. var. *oleiformis* Pers. (GRIN) (NOPD)
- *Raphanus sativus* L. f. *raphanistroides* Makino (NOPD) -> *Raphanus raphanistroides* (Makino) Nakai (NOPD) (Mansf)
- *Raphanus sinensis* Sinskaya (Mansf) -> *Raphanus sativus* L. (Chinensis Group)
- *Raphanus sylvestris* Lam. -> *Raphanus raphanistrum* L.

The origin of the oil radish – *Raphanus sativus* L. var. *oleiformis* Pers. is also currently controversial. The description of the general genetic structure of the cruciferous family was carried out by Sinska (Filatenko et al., 2003). Her works (Synska, 1926, 1928, 1931, 1948, 1963, 1969) emphasize its origin in East Asia. There are hypotheses that oil radish was cultivated in prehistoric times in the Middle East, and in particular in Egypt, as an oil plant.

The research of Bloimer (1901) points to the origin of oil radish from the common wild radish. However, it is noted that it may be an older form than the wild radish. The same opinion was shared by other researchers on this issue (Gereau, 1923). It is reported that the systematics of cruciferous plants, in particular the genus *Raphanus*, is one of the most complex

and there is still no final opinion on its hierarchy. There are a number of different approaches to the genetic interpretation of the relationships of the genus *Raphanus*. One of the most thorough is the variant presented in the works of Synska, however, another monograph on the genus *Raphanus* by Zhukovsky (1971) did not share her views on the species differentiation of *Brassica*. In his studies, it was repeatedly emphasized that the main thing is to understand the species as a three-dimensional taxon. Among cultivated *Brassica* there are many cultivars that do not have botanical and genetic rights to the rank of species. The cytogenetics of *Brassica* is still poorly developed. We have some idea of the very complex evolution of *Brassica*, but under these conditions we should proceed from the understanding of the species as a large taxon with intraspecific complex differentiation. According to Zhukovsky (1971), approaches to this problem based only on the morphological clade of the species are wrong.

These features are noted in the studies of Synska's predecessors, who unilaterally considered the issue of the genetic origin of oil radish in view of its morphogenetic structure. Thus, Batalin (1879) and Fedorov (1912) attributed this plant to the wild ancestors of cultivated radish varieties. Kalinovsky (1980, 1982) believed that oil radish originated from China and Japan as a form of garden radish.

Blomeyer (1901) refers to it as a type of garden radish with the primary center of origin in western Asia, between Palestine and the Caucasus from the field radish (rape, swarup) *Raphanus raphanistrum* L.

The same conclusions were made by D. N. Pryanishnikov (Werner, 1985), ignoring the different color of the petals. He explained this discrepancy by the fact that *Raphanus raphanistrum* L. has purple streaks in yellow petals on some soils.

On the other hand, Komarov (1938) and Decandol (1985) denied the origin of oil radish from field radish. In support of this, they pointed out that ancient peoples could not pay attention to the field weed and improve it to obtain edible roots, but they did not deny the European origin of the genus *Raphanus*, despite the fact that the inhabitants of India, China, and Japan have been growing radish since ancient times.

In contrast to these claims, Komarova (1938) points to the East Asian origin of the oil radish: in the course of economic relations between the peoples of China and Central Asia, it spread to Asia. This fact has been confirmed by archaeological research.



**Figure 1.2 – Oilseed radish in crops
on the experimental field of Vinnytsia National Agrarian University
(in different years of the period 2013–2024)**

Shlapunov (1982) considers *Raphanus maritimus* Sm. to be the most likely ancestor of the radish, which grows off the coasts of northern Spain, Ireland, Scotland and Britain. It is a biennial plant with yellow flowers and the same spongy fruits as the cultivated radish. Komarov (1938) and Mikhailova (1975) in their dissertations, based on scientifically based results, also argue that *Raphanus raphanistrum* L. does not correspond to the flora of Asia.

Karpechenko (1968, 1974) genetically approximates wild radish with the seed radish on the basis of the same number of chromosomes – 18. However, he notes that this fact is evidence of a common ancestor of the genus *Raphanus*.

Synska in her early works (1926, 1928, 1931) believed that the homeland of radish crops was China and suggested that a wild weed form, the ancestor of radish, would be found in eastern China or another area. She emphasized the fact that many Chinese and Japanese forms of root radishes did not produce thickened roots under the conditions of a longer northern day, bloomed quickly, and were morphologically similar to oil radish.

Based on the results of her experiments on hybridization of oil radish with radish, seed radish and wild radish, Sinnaya (1926) concluded that the roots of wild radish and oil radish are of genetically different nature, that oil radish is heterozygous in terms of root traits and that by selection it is possible to obtain a genus with thick, hard roots, i.e., similar in appearance to wild forms of the root crop. In her later works, Sinnia (1963, 1969) suggested its more likely origin from ancient Egypt. She also pointed to the insufficient study of the variability of its morphotypes. Some of its forms have the same fruit structure as the Chinese radish. She admits the possibility that oil radish is a fine-rooted form of radish: in China, of Chinese origin, and in Europe, of European origin. Some foreign authors Kovarskaya, Lysakova, Geishin and Rosenthal (Sinskaya, 1969) believe that oil radish originates from the common sowing radish, since under the influence of temperature and day length, the root form can produce plants without roots, but with the formation of a flower stem and seeds.

Thus, according to Radchuk and Blum (2005), the question of the genetic and geographical origin of oil radish remains open. Recent studies on the origin of oil radish have been translated into the perspective of species genetic analysis and genetic phylogeny and have been concentrated

Systematized data on the taxonomy and origin of oil radish are presented in the form of a grouped data set below.

Vernacular names:

- English: fodder radish, oil radish, oilseed radish
- Deutsch: Ölrettich
- Español: rábano oleaginoso
- Français: radis fourrager, radis oléifère
- Hornjoserbsce: Wolijowa rjetkej
- Magyar: olajreték
- Italiano: rafano da foraggio
- Nederlands: Bladrammenas
- Português: rábano-de-azeite, nabo-forrageiro
- Türkçe: kestane turbu
- Portuguese: rabão-de-azeite
- Spanish: rabano oleaginoso
- Swedish: olierättika

Taxonomy ID: 463157 (for references in articles please use NCBI:txid463157) current name

Raphanus sativus var. *oleiformis* Pers. (Persoon), 1806

- [or *R. sativus* Leaf Radish Group]
- Persoon, in indicating '*chinensis oleiformis*' and citing 'Willd.'

Sp. III. p. 560' under this species, provided an indirect reference to the diagnosis 'R. chinensis annuus oleiferus' of the unnamed variety of Willdenow and Linnaeus (Sp. pl. ed. 2, 2:935. 1763) (Shenzhen ICN 38.14)

NCBI BLAST name: **eudicots**

Rank: **varietas**

Genetic code:

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AAs = FFLSSSSYY**CC*WLLLLPPPHHQRRRIIIMTTTTNNKSSRRVVVAAAAADDEEGGGG
Starts = --M-----**-*---M-----M-----
Base1 = TTTTTTTTTTTTTTTTCCCCCCCCCCCCCAAAAAAAAAAAAGGGGGGGGGGGGGGGGGG
Base2 = TTCTCCCCAAGGGGTTCCTCCAAAAGGGGTTCCTCCAAAAGGGGTTCCTCCAAAAGGGG
Base3 = TCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAG
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AAs = FFLSSSSYY**CC*WLLLLPPPHHQRRRIIIMTTTTNNKKSRRVVVVAADDEEGGGG
Starts = --M-----**-*-M-----M-----
Base1 = TTTTITTTTTTTTTTTCCCCCCCCTTTAAAAAAAAAAAAAGGGGGGGGGGGGGGG
Base2 = TTTCATCCCCAAAGGGGTTCCTCCAAGGGGTTCCTCCAAGGGGTTCCTCCAAGGGG
Base3 = TCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAG
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Raphanus chinensis Mill., Gard. Dict. ed. vol. 8, no. 5. 1768.
Raphanus sativus var. *oleiformis* Pers. Syn. vol. 2, 482. 1812.
Raphanus sativus var. *oleiferus* Stokes, Bot. Mat. Med. vol. 3, 482. 1812.
Raphanus sativus var. *chinensis* (Mill.) Alef., Landw. Fl., 258. 1866.
Raphanus sativus convar. *oleiferus* (Stokes) Sazon. & Stankev., Kult. Fl. SSSR vol. 18, 209, comb. superfl. 1985.

Raphanus raphanistrum f. *chinensis* (Mill.) Thell. in Hegi., Ill. Fl. Mittel-Eur. vol. 4, 1, 280-281. 1918.

Raphanus sativus subsp. *oleiferus* (Stokes) Metzg. Landw. Pflanzenk. vol. 2, 1059. 1841.

Raphanus raphanistrum f. *longirostris* Thell. in Hegi, Ill. Fl. Mittel-Eur. vol. 4, 1, 280-281. 1918.

Raphanus sativus L., Sp. Pl. ed. vol. 2, 935, quoad γ. 1763.

Raphanus sativus var. *caudatus* Alef., Landw. Fl., 258. 1866., non , non var. *caudatus* Vilm. 1925 (non *R. caudatus* L.f. 1767).

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CHAPTER 1

Familia: Brassicaceae • Tribus: Brassiceae • Genus: Raphanus • Species: Raphanus sativus Pers., 1806.

CollapseTaxonomy

Kingdom Plantae
Subkingdom Viridiplantae
Infrakingdom Streptophyta
Superdivision Embryophyta
Division Tracheophyta
Subdivision Spermatophytes
Order Brassicales
Family Brassicaceae
Tribe Brassiceae
Genus Raphanus
Species Raphanus sativus
Variety Raphanus sativus var. oleiformis

KingdomPlantae (1PLAK)

PhylumMagnoliophyta (1MAGP)

ClassAngiospermae (1ANGC)

CategoryMalvids (1MAVD)

OrderBrassicales (1CAPO)

FamilyBrassicaceae (1CRUF)

GenusRaphanus (1RAPG)

SpeciesRaphanus sativus subsp. oleiferus (RAPSO)

Associated Non-Taxonomic

brassica arable crops (3BRAC)

CollapseAuthority file

NCBI taxonomy ID: 463157

BioLib taxon ID: 132243

GBIF taxon ID: 4928064

Tropicos ID: 50156489

GRIN URL: <https://npgsweb.ars-grin.gov/gringlobal/taxonomydetail.aspx?id=319666>

aspx?id=319666

PfaF ID: Raphanus sativus oleiformis

uBio ID: 5877259

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- ***Preferred name:*** *Raphanus sativus* subsp. *oleiformis*
- ***Authority:*** Persoon, Stokes, Metzger

1.2. Morphological portfolio of oilseed radish

Oilseed radish is characterized by a number of morphobiological features that qualitatively distinguish the crop from other cabbages.

Its root is taproot (Figure), thickened in diameter to 2–3 cm near the root collar. Thickening can reach even higher values of up to 4–6 cm and is determined by the sowing time and the area of plant nutrition (Tsytisura and Tsytisura, 2015, Figures 1.3–1.10). The depth of root penetration depends on the mechanical composition of the soil: on light soils it reaches values up to 60–80 cm, and on heavier soils – 50–60 cm. The bulk of the roots are located at a depth of 25–30 cm, which should be taken into account in the crop's agricultural technology.

The most intensive growth of the root system of oilseed radish is observed from the rosette phase to the budding phase. In the northern regions, the growth of the root system in the interphase period of germination – budding was 1.1 cm day⁻¹, budding – flowering – 0.6 cm day⁻¹, flowering – physiological maturity 0.3 cm day⁻¹. Moreover, in some studies it is noted that in the northern latitudes the growth of the root system is limited to the interval of 0.5–0.7 cm day⁻¹ (Tsytisura and Tsytisura, 2015), and when oil radish moves south – 0.8–1.3 cm day⁻¹ (Kengbaev, 1986).

The development of the root system of oil radish is determined by the natural and climatic zone of its cultivation and the timing of sowing. Thus, according to Kuznetsov (1976), the roots of oil radish under optimal growing conditions can penetrate the soil to a depth of 1 m. Pilyuk (1984) studied the depth of penetration of oil radish roots 30, 45 and 60 days after sowing (Table 1.1) in spring post-cutting and post-harvest crops. Her observations showed that on medium loamy sod-podzolic soils, 60 days after sowing, the root system of oil radish penetrates to a depth of 57.3 cm in spring, 70.1 cm in post-cutting and 57.8 cm in post-harvest crops. The most intensive average daily root growth occurs in radish during the budding-flowering period, i.e. 45–60 days after sowing in spring (1.5 cm) and (1.90 cm) in post-harvest crops.



Figure 1.3 – Roots of oil radish plants in the period of cotyledon leaves (electronic magnification 200x using a Sigeta Cam USB microscope hereafter)



Figure 1.4 – The area of the root collar of oil radish variety Raduga during the formation of true leaves (the characteristic anthocyanin color of the upper part of the root is noticeable)

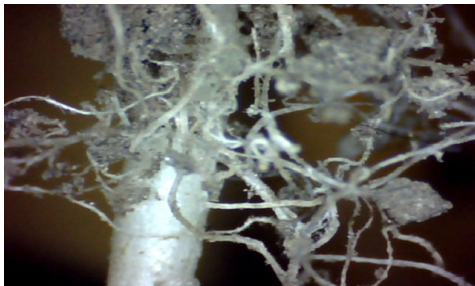


Figure 1.5 – Root system of oilseed radish variety Zhuravka during budding with active formation of the suction zone (electronic magnification 200x)



Figure 1.6 – General view of oil radish (Vavilov and Balyshev, 1984):
1, 2 – plants in the phases of flowering – fruit formation
and germination; 3 – upper part of the stem in the flowering phase;
4 – fruit; 5 – seeds (upper position – enlarged)



Figure 1.7 – The nature of the development of the root system of the variety ‘Raduga’ in the phase of the beginning of stemming on the example of 7 plants sequentially selected along the length of the row (seeding rate of 2.0 million units/ha of similar seeds on the background of $N_{60} P_{60} K_{60}$, 2011)

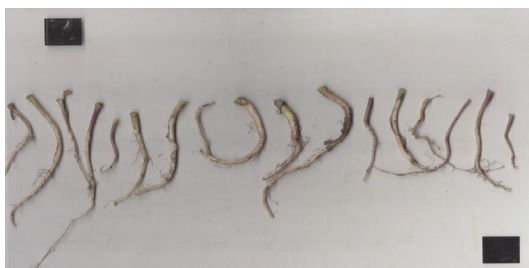


Figure 1.8 – Variation in the development of the root system of oilseed radish plants of ‘Zhuravka’ variety during the period of rosette formation



Figure 1.9 – Root diameter at the base of the root collar of oilseed radish variety ‘Zhuravka’ depending on the seeding rate (from left to right: 0.5 million, 1.0 million, 1.5 million, 2.0 million, 3 million germinating seeds per hectare)

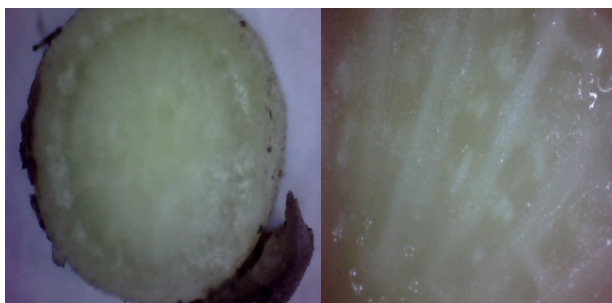


Figure 1.10a – Cross-section of root thickening of oilseed radish at different magnifications

Table 1.1

Growth and average daily growth of the root system of oil radish, cm (cm day⁻¹) Pyluk (1984)

Sowing option	30 days after sowing		45 days after sowing		60 days after sowing	
Spring sowing	19.6	0.65	34.7	1.01	57.3	1.51
Post-cutting	22.5	0.75	41.7	1.28	70.1	1.90
Post-harvest	27.3	0.91	44.6	1.15	57.8	0.88

In the post-harvest crops for all years of research, more intensive development of the root system was noted 30–45 days after sowing, which reached 1.15 cm per day. In the future, the intensity of growth of oil radish roots in post-harvest crops decreases the most intensive growth of the root system of oil radish in the first 30 days after sowing is observed in post-harvest crops and averages 0.91 cm per day. In 45–60 days after sowing, more active root growth of this crop was observed in post-harvest crops (1.28 and 1.90 cm per day). In general, oil radish is characterized by a fairly intensively developed root system, capable of penetrating under favorable conditions during 60 days of vegetation to a depth of 65–75 cm. At the same time, the nature of root distribution depends on the soil and climatic zone of crop cultivation. For example, in the northern regions of the Eurasian continent, the root system of oil radish is concentrated in the 0-25 cm horizon (up to 70–75% of roots), and the soil layer of 20-70 cm accounts for 12–25% of roots (Figure 1.11–1.14 (a-d).

In central areas with sufficient moisture, the ratio in the distribution of the root system shifts to deeper horizons. Thus, the soil layer of 0–25 cm already accounts for 45–65% of the roots, and deeper horizons account for up to 25–35%.

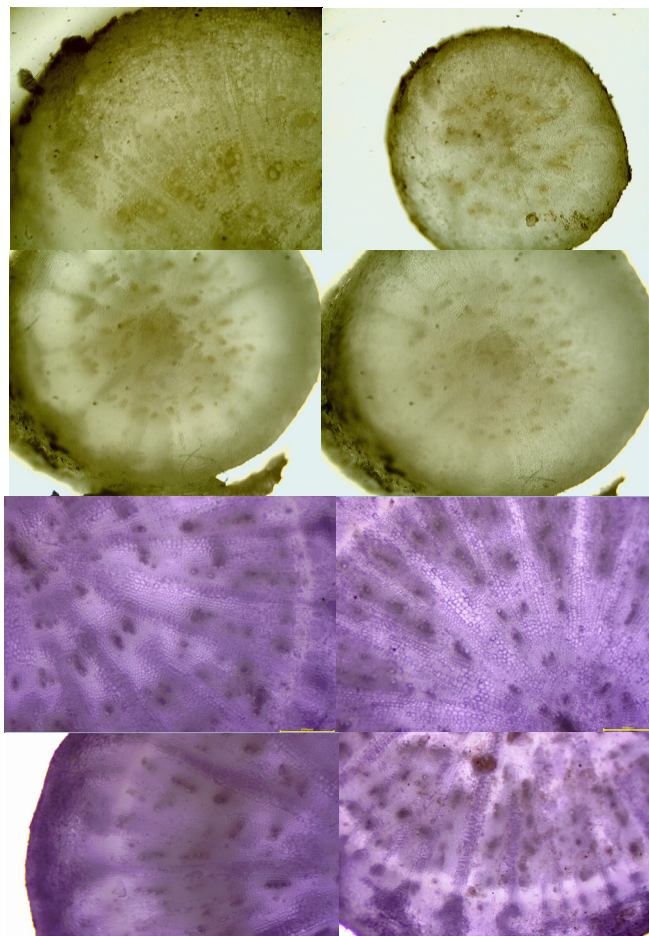


Figure 1.10b – Cross-section of root thickening of oilseed radish at different magnifications

It should be noted that in arid zones and areas of the Far North of the Eurasian continent, the productivity of the root system of oil radish is 4.50–5.70, which positively distinguishes it among a number of traditional agricultural crops.



Figure 1.11 – Longitudinal section of oilseed radish root thickening in the suction zone



Figure 1.12– Root system of oilseed radish 'Zhuravka' variety during the fruiting period



Figure 1.13 – Variation series of root thickening development of oil radish plants of ‘Zhuravka’ variety depending on the seeding rate (from left to right 3, 2, 1.5, 0.5 million germinating seeds/ha), 2012



Figure 1.14 – Nature of root system development in plants selected from an area of 0.25 m² for ‘Raduga’ variety at a sowing rate of 1.5 million seeds/ha of similar seeds with N₆₀P₆₀K₆₀, 2012



Figure 1.14a – Root systems of oilseed radish at the seedling stage (BBCH 6–8) and rosette stage (BBCH 12–16)



Figure 1.14b – Variants of morphometry of oilseed radish roots in the phenological phase of flowering (BBCH 58–64)



Figure 1.14c – Comparison of the morphometry of the root systems of oilseed radish and other typological representatives of cruciferous species

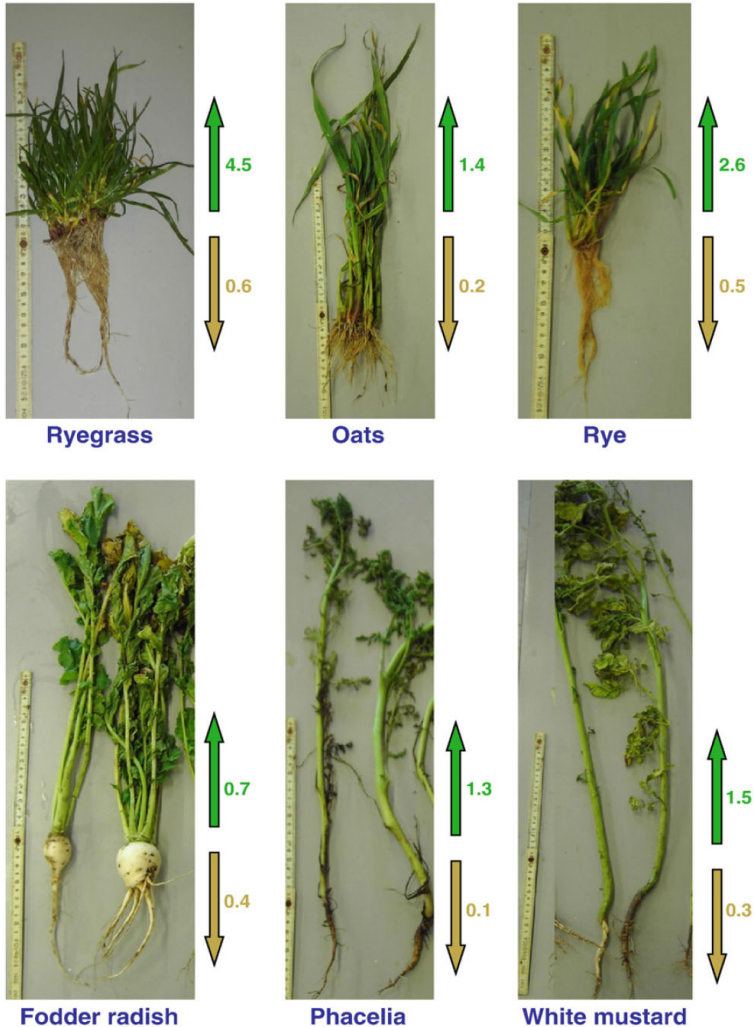


Figure 1.14d – Illustration of above-ground and below-ground biomass of 6 cover crops with indication of the allocation of biomass to roots (downward arrow) and shoots (upward arrow). Values are in tons (t) dry matter ha⁻¹ (Baets et al., 2011)

The stem of oil radish is capable of branching (Figures 1.15–1.16), curved at the nodes in cross-section, 3–5 faceted, and has intense pubescence. The color of the plants of the crop is a varietal trait that varies from intense green to bluish-green. The color of plants in oil radish is an additional indicator of mineral nutrition (Zinchenko, 2005), a reaction to stress factors (Krivitsky et al., 1981), and a criterion of ripening (Shpaar, 1999). The vast majority of oil radish varieties of domestic selection have a light green color, and varieties of foreign selection have an intense green color (Batarchuk, 1990). The stem is hollow during flowering – full ripeness, but the nature of its fullness depends on the phenological phase of plant development, their water content during the growing season, temperature conditions during budding – flowering, and plant nutrition area (Figures 1.17–1.25).



Figure 1.15 – Formation of lateral shoots in the axils of the leaf blade petiole in oilseed radish ('Raduga' variety) (lateral shoots appear, as a rule, in the axils of 3–6 leaves)

Thus, during the period of stem formation (stemming phase), plants are characterized by a fully filled stem with juicy parenchyma. When the stem is cut during this phase, active sap flow is observed. The formation of heart-shaped parenchyma, which in oil radish has a bright white or cream color, begins from the stemming phase, so that at the budding stage, signs of its presence are visible on the cross-section of the stem in the naked eye in the young parts of the stem (Figures 1.16).



**Figure 1.16 – Lateral shoots in the axils
of the petiole of the leaf blade in oilseed radish ‘Zhuravka’ variety**

Subsequently, in the course of plant maturation, qualitative transformations in the filling tissues of the stem cause maceration of the stem core and morphogenesis of the stem tissues of the hypodermal ring, accompanied by an increase in the proportion of mechanical tissues, an

increase in the percentage of fiber in the leaf-stem mass and a decrease in its moisture content.



Figure 1.17 – The nature of pubescence of the stem of oilseed radish variety ‘Raduga’



Figure 1.18 – Transverse section of an oil radish stem of ‘Zhuravka’ variety at the beginning of stemming (signs of the core are not clearly visible and not clearly expressed)

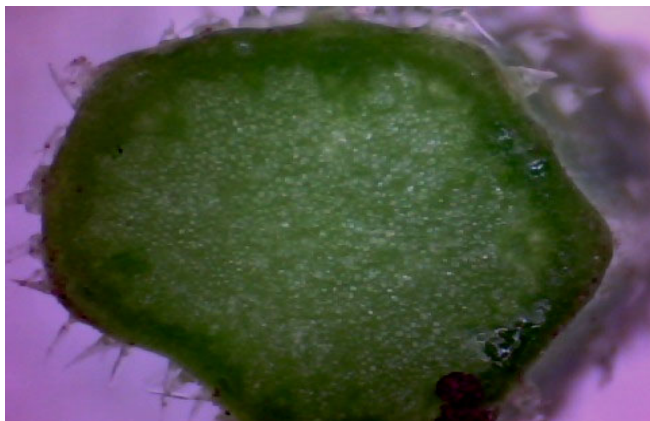


Figure 1.19 – Transverse section of an oil radish stem of the ‘Raduga’ variety at the beginning of stemming (the central core is not expressed, only formed)



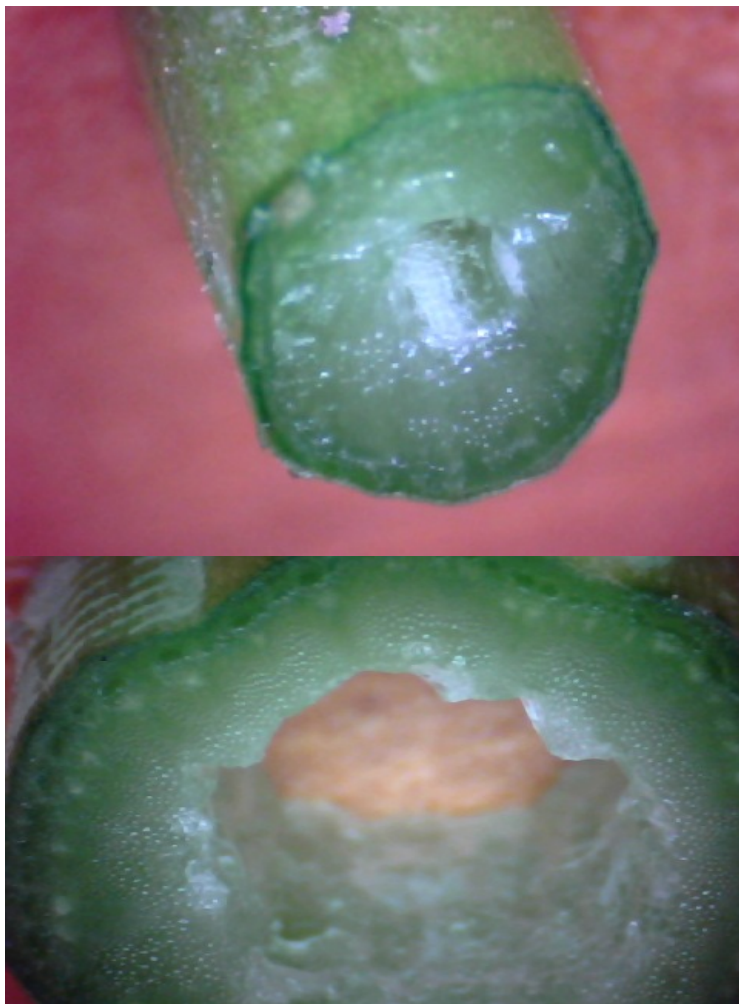
Figure 1.20 – The formed core of the stem of oilseed radish variety ‘Zhuravka’ at the phenological phase of budding



Figure 1.21 – Filling parenchyma of the plant stem during the period of stemming – budding



Figure 1.22 – The beginning of maceration of the stem core during the flowering period of oilseed radish variety ‘Zhuravka’



**Figure 1.23 – Oilseed radish stem in cross-section
in the flowering phase (upper position – peduncle zone,
lower position – zone of the lower root part of the stem)**



Figure 1.24 – Transverse section at the base of the stem of Zhuravka variety in the phase of green pod with pronounced maceration of its core (250x electronic magnification)



Figure 1.25a – Longitudinal section of the stem of Zhuravka variety (electronic magnification 200x)

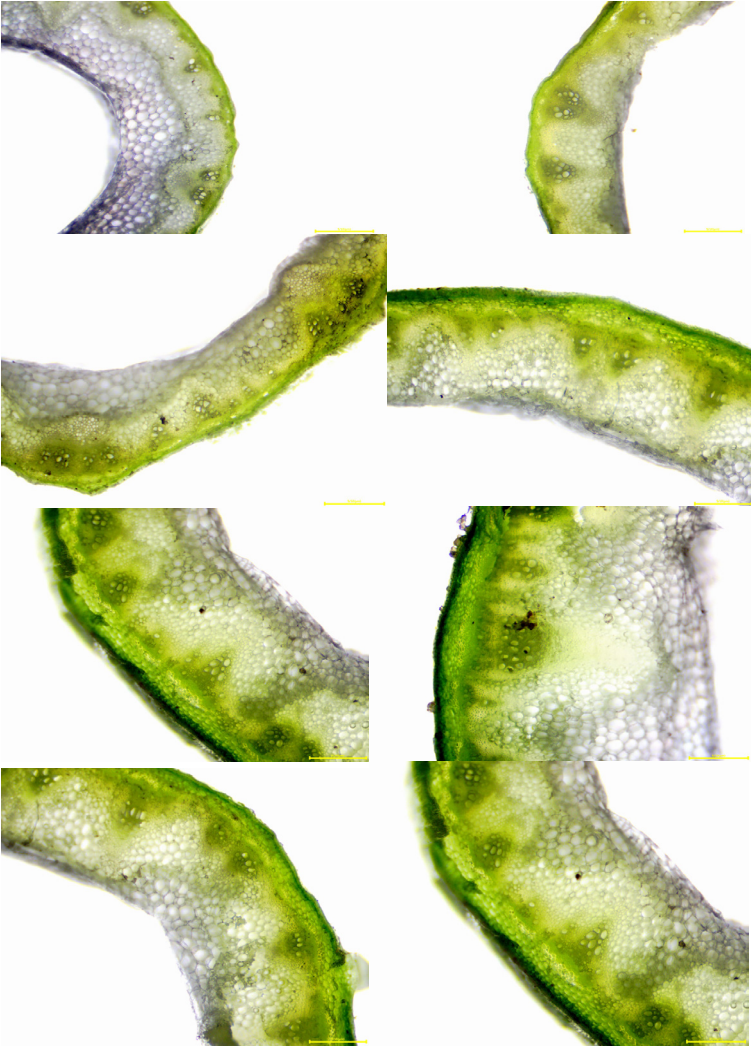


Figure 1.25b – Anatomical structure of oil radish stem walls during the flowering phase (BBCH 54–60) (cross section)

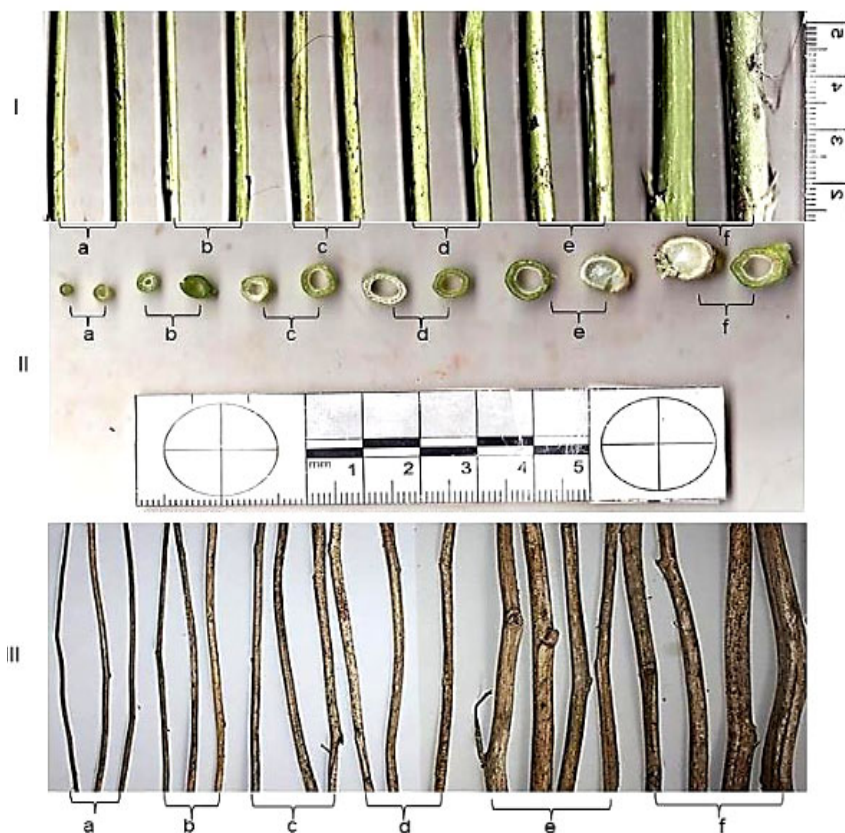


Figure 1.26 – Dynamic series of stem diameter at the base within the analyzed array of pre-sowing design of oilseed radish, 2019 (I – stems at the green pod stage of BBCH (62–65); II – cross-section of the stem at the base for the green pod phase (BBCH 62–65); III – stems for the phenological phase of the brown pod (BBCH 84–87); typical plant stems and its diameter cross-sections at the base against the background of $N_{90}P_{90}K_{90}$ application at the seeding rate (million germinating seeds ha^{-1}): row sowing a –4.0; b –3.0; c –2.0; wide-row sowing: d –1.5; e –1.0; f –0.5

The height of the stem of oil radish reaches its maximum value during the period of full flowering – fruiting. The value of this indicator can vary from 35 to 140 cm and depends on the complex of soil and climatic conditions, sowing time, varietal characteristics and fertilization (Shcherbakov, 2000). Oil radish is characterized by the ability to bloom very early, under certain conditions – the plant blooms at a stem height of 25–30 cm, and in some cases even at 12–18 cm, which plays an important role in the formation of such an indicator as reproductive effort (Tsytsiura, 2019).

The leaves of the middle part of the plant are lyre-shaped and periseptate, and the upper part is lyre-lobed (Tsytsiura, 2020a. Figure 1.27), with certain patterns in venation, mesophyll thickness, and stomatal apparatus tropism (Figure 1.28, 1.28 (a–c)) with intense pubescence, especially in the early stages of formation and growth. The length and width of leaves and their morphology varies widely, depending on a wide range of factors from the level of mineral nutrition to water consumption conditions during the growing season (Tsytsiura, 2020a). The number of leaves per plant is a highly variable trait and ranges from 6 to 15 at a particular developmental stage. In the southern regions, when growing oilseed radish, the number of leaves is less than 6 to 9, in the northern regions the number of leaves can be higher than 12 during certain periods of the plant's vegetation. Thus, the leafiness of oilseed radish depends on the growing conditions. The share of leaves in the northern latitudes with optimal moisture accounts for 60–75% or more. As oilseed radish moves southward, the share decreases to 25–50% and even 15–20% (Tsytsiura, 2020a). Oilseed radish has a high potential for the formation of an assimilation surface from 150 thousand m² per hectare to 25 thousand m² per hectare (Krivitskyi, 1986; Radchenko, 2009; Drabek, 2011; Kozlenko, 2011). The area of its leaf apparatus, as well as that of any agricultural crop, is determined by weather conditions, mineral nutrition, methods and timing of sowing, varietal characteristics and has a maximum expression from the budding phase to the flowering phase with a subsequent decrease due to the death of some leaves during fruiting (Kozlenko, 2011).



Figure 1.27 – Variability of leaf shape of Zhuravka oil radish plants (top position – 2012, bottom position – 2010 (leaves characteristic of the upper part of plants 9 – 25 are lyriform-lobed, middle 1 – 4 – lyriform-peripinnate, lower 5 – 8 – peripinnate))



Figure 1.28 – Venation pattern of oil radish leaves of ‘Zhuravka’ variety (2010), which obeys Zelensky’s law regarding the number of conductive bundles per unit area of the leaf with changes in the tier of their placement (a, b, c – respectively, leaves of the lower, middle and upper tier)



Figure 1.28a – Scanned assimilation surface of a typical oilseed radish plant at a sowing rate of 0.5 million seeds ha⁻¹ of similar seeds in the background with N₆₀P₆₀K₆₀ (2 cm² black marker square)



Figure 1.28b – Scanned assimilation surface of 6 typical oilseed radish plants at a sowing rate of 3.0 million seeds/ha of similar seeds in the background with $N_{60}P_{60}K_{60}$ (2 cm² black marker square)



Figure 1.28c – A number of morphotypes of oilseed radish leaves of different layers of placement



**Figure 1.29 – Character of pubescence of different parts
of oil radish variety Zhuravka**

The highest fodder productivity of oil radish was observed at the presence of 40–60 thousand m²/ha of leaf area in the flowering phase (Krivitsky, 1986; Rakhmetov and Kozlenko, 2008).

There is little literature on the biology of oil radish flowering. It is characterized by the fact that the differentiation of the growth cone begins in the phase of two true leaves. The second-order growth cone is formed, i.e. the growth points of the rudimentary flowers. The intensity of the second-order growth cone formation process determines the potential number of flowers in the future inflorescence. This process is very extended in time. It does not decay to the same extent as in other crops, such as cereals, due to the transition of the most developed inflorescence flowers to further stages of organogenesis. Significant heterogeneity of the emerging inflorescence as the flowers develop occurs in the early stages of organogenesis and persists until the seeds ripen.

Before flowering, the inflorescence is relatively compact and can be divided into separate lobes. Each such lobe is the future inflorescence, i.e. a peduncle with more or less flowers is formed on each lobe.

The central lobe of the inflorescence has undifferentiated flowers, and the most developed ones are located on the periphery. During the flowering period, when the peduncles are elongated and the inflorescence acquires the appearance of a brush, the most developed peripheral flowers are at the same stage of organogenesis. The number of inflorescence lobes before flowering mainly determines the number of flowers on the main axis. Peduncles in oil radish are often formed from axillary buds. Axillary inflorescences, like apical inflorescences, have several lobes and with their development the plant acquires the characteristic appearance of a branched bush. But axillary buds do not always develop, especially in the axils of the lower leaves.

Flower formation begins with the formation of a meristematic tubercle (Figures 1.30–1.31), on which sepals are first laid, followed by stamens and pistils, and much later corolla petals. Before budding, the sepals close and cover the stamens and the pistil column. During this period, the formation and growth of corolla petals begins. In the budding phase, intensive growth of all flower organs is observed. At the beginning of budding, the length of the flower does not exceed 0.5–0.6 cm, and before flowering, the flower reaches 1.5–1.8 cm in length.



Figure 1.30 – Ontogeny of oil radish flower.

- 1 – the beginning of the laying of floral meristematic zones;
2 – flower formation; 3 – flowers before budding



Figure 1.31 - Growth and development of an oil radish flower.

- 1 – before the beginning of budding (the beginning of the perianth petal mouth); 2 – at the beginning of budding;
3–4 – during the budding phase (further growth of perianth petals, stigma and anthers is observed); 5 – before flowering (perianth petals completely cover the pistil and anthers)

Oilseed radish has no bracts. The flowers are bisexual, bilaterally symmetrical. Sepals 4, in 2 circles, the inner ones at the base with saccular outgrowths (Figures 1.32–1.40). Petals 4, with pronounced nails. Stamens 6, 2 of them short and 4 long. At the base of the stamen filaments, in different numbers and arrangements, there are outgrowths of the flower axis. The arrangement of nectaries in oil radish is typical for the cruciferous family: the flowers contain two large arched nectaries located between the ovary and short stamens. They secrete nectar. There are also two small underdeveloped nectaries between the long stamens, but they do not secrete nectar. The ovary is upper, of 2 carpels, 2-nested with permanent placentation and a different number of anatropic or campylotropic seed embryos with 2 integuments. Column with a capitate or 2-lobed stigma.

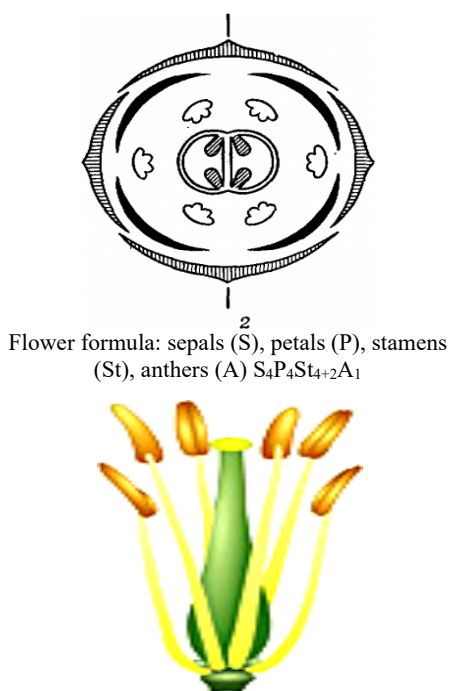


Figure 1.32 – Flower formula and structure of androecium and gynoecium in oil radish (type 3 flower)

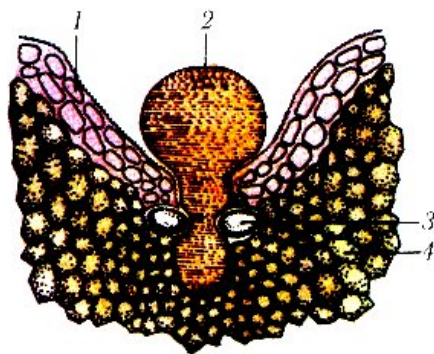
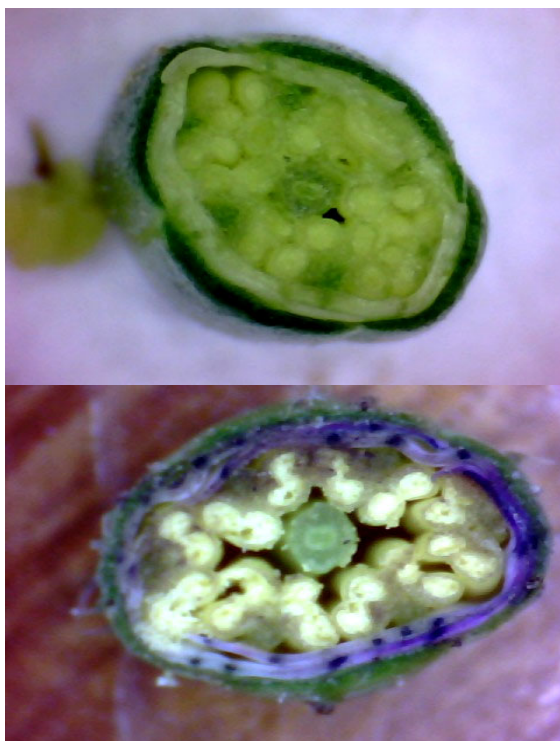


Figure 1.33 – Section of a typical nectarifer (Ponomareva and Deterleva, 1986) (1 – epidermal cells; 2 – nectar; 3 – cells that regulate the protrusion of a nectar drop; 4 – cells of nectar-bearing tissue)



Figure 1.34 – Longitudinal section of oil radish buds of Raduga variety at the beginning of budding (morphological rudiments of petals, stamens and pistils undifferentiated in color are visible)



**Figure 1.35 – Transverse section of oil radish buds
of the Raduga variety (upper position – at the beginning of budding,
lower position – before flowering)**

The flowers of oilseed radish are heterogeneous and both heterostyledonous and homostyledonous flowers are found in the population. There are 3 types of flowers: 1) the column is short, so that the stigma reaches only the lower edge of the anthers; 2) the stigma and anthers are at the same height; 3) the column is long and the stigma rises above the anthers. The 2nd and 3rd types of flowers usually prevail. According to Bazylev (1981), the number of flowers with long columns in the population of oil radish reaches 89%, according to other data (Radchenko, 2009) – no more than 53–55%. Recent studies have identified 2 more types of flowers

in the oil radish population: 1) flowers with a well-developed pistil stigma, and stamens rising above the stigma only to the size of anthers; 2) stamens not equal in length (Figure 1.41).



**Figure 1.36 – Oilseed radish buds of the Raduga variety
(upper position – at the beginning of budding, lower position –
before flowering)**



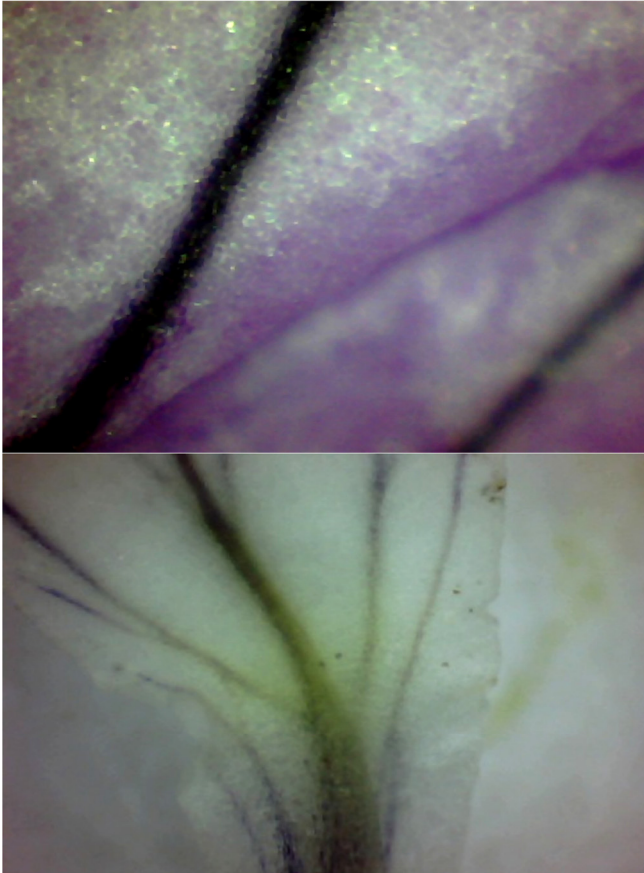
**Figure 1.37 – Longitudinal section
of oil radish buds of ‘Zhuravka’ variety before bud opening
(lower position – flower receptacle)**



Figure 1.38 – Anthers and pistil with a column of oilseed radish flower of ‘Zhuravka’ variety

The flowering of oil radish begins with the main axis of the inflorescence, then the brushes on the second-order lateral shoots bloom (Figure 1.42–1.47). The clusters always bloom in an acropetal direction. In summer, the flowers open at 6–7 am. In autumn, this period shifts to 9–10 o’clock, and with a drop in temperature to 10 °C, the flowering time shifts to a later time. The flowering time of one flower is 2–3 days

and depends on the air temperature. In all types of flowers, anthers at the beginning of flowering are turned with their opening side to the stigma, and later they are angled outward, so that pollen does not fall on the stigma of this flower (Figures 1.47–1.49). Thus, the structure of the flower and the arrangement of the anthers before the pollen ripens makes self-pollination impossible and occurs in very rare cases.



**Figure 1.39 – Petals of oilseed radish flowers
(top position – ‘Raduga’ variety, bottom position – ‘Zhuravka’ variety)**



**Figure 1.40 – The nature of pubescence of oil radish buds
(magnification 200x)**

The color of the flowers is one of the varietal traits and is mostly white, but pink, purple, and yellowish can also occur (Figures 1.46–1.47).

Oil radish, as mentioned earlier, has unique properties in terms of juvenile flowering, when the plant blooms at a stem height of 15–30 cm (Bazylev, 1981), and in some cases even at 10–15 cm (Kengbaev, 1986) (Figure 1.48). Such a flowering pattern is primarily associated with unfavorable hydrothermal regime of vegetation, especially under conditions of a sharp increase in the average daily temperature against the background of a prolonged soil moisture deficit. Under these conditions, oil radish plants develop slowly in terms of morphological traits (height, number of leaves, etc.) and undergo accelerated qualitative differentiation. That is why radish is able to bloom in this way during prolonged drought.

Moreover, it was noted that juvenile flowering is characteristic of 5-10% of plants. This fact plays an important role in the formation of such an indicator as reproductive effort (RE (Kengbaev, 1986a), which affects the level of seed productivity of the crop and its adaptive potential – oil radish is able to form a certain minimum of seeds even under the most unfavorable

conditions of its growth and development. Thus, according to H. F. Batyrov (Kengbaev, 1983), in the conditions of the Republic of Uzbekistan, oilseed radish in a short growing season of 20–25 days, due to the intensive increase in temperatures in March-May for the conditions of Central Asia, formed inflorescences on 8–12% of plants and provided seed productivity at the level of 35–50 kg ha⁻¹.



Figure 1.41 – Pistil of oilseed radish flower pistil of different types by the height of the stigma (top position – ‘Zhuravka’ variety, bottom position – ‘Raduga’ variety)



Figure 1.42 – The beginning of flowering of the main axis of the inflorescence in the variety Rainbow (upper position). Differentiation in the flowering of the main axis with formed pods and axes of the following orders (formed flowers and buds) (lower position)



Figure 1.43 – The beginning of the opening of an oil radish flower of the Zhuravka variety



**Figure 1.44 – Flower of oil radish variety Zhuravka
(upper position – during the opening period, lower position –
during the period of active flowering)**



**Figure 1.45 – Oilseed radish flowers of different varieties
(top position – Raduga variety, middle position –
‘Zhuravka’ variety, bottom position – Compass variety)**



**Figure 1.46 – Inflorescence of oil radish variety ‘Raduga’
(the variety is characterized by white or pale yellow flowers)**



**Figure 1.47 – Inflorescences of oil radish variety ‘Zhuravka’
(the variety is characterized by pale purple or pink-purple flowers)**



Figure 1.48 – “Juvenile” type of flowering of oil radish under unfavorable hydrothermal conditions of vegetation

The formation of flowers and the number of fruits set is determined by both environmental factors and the nature of the plant itself. It has also been found that with prolonged cultivation of oil radish in northern conditions, the pubescence of its flowers is significantly reduced.

The time of flower opening, as well as the order of inflorescence flowering, can change under the influence of stress factors (a sharp increase in temperature, a sharp decrease in air humidity, etc.) (Dudka, 1993).

Oil radish can be well pollinated both by insects and wind (Figure 1.49). 1 to 2 days before opening, the flower is ready for fertilization. Therefore, researchers involved in oil radish breeding need to take this feature of its development into account.

The future seed productivity of oil radish may be determined by the nature and intensity of inflorescence flowering and the reproductive efforts of the plant itself (Tsytisiura, 2021), which is an under-studied issue for the conditions of the Ukrainian Forest-Steppe. The formation of generative organs is extended in time. The intensity of their formation is determined

by the level of nitrogen nutrition, temperature conditions during flowering, and sowing dates (Kryvytskyi, 1986).

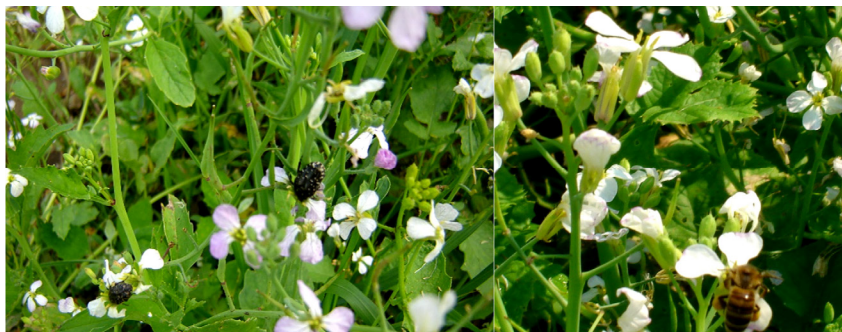


Figure 1.49 – Insect pollinators on oilseed radish crops

The fruit is a thickened pod with a sharp tip, 4-8 cm long and 1-1.5 cm in diameter, convex, without bands with thickened walls. The pods of oil radish have different shapes and sizes within the inflorescence depending on their placement on the branches of the corresponding order (Tsytsiura, 2022, Figures 1.50-1.55). This fact is important for understanding the patterns of seed formation within the inflorescence and the formation of seed productivity of the crop. A positive characteristic in the structure of the fruit is its strength, high mechanical resistance to cracking, which prevents seed shedding and its preservation from the adverse effects of external factors, but this feature is an obstacle to effective threshing. In addition, the inside of the pods contains a large amount of parenchymal tissue with high hygroscopicity, which creates additional difficulties when harvesting in rainy weather, which are solved in production by desiccation (Sedlyar, 1984). Due to their different phenology within the inflorescence, pods ripening is also uneven, especially in rainy weather during the ripening period. As a rule, the pods of the main axis of the inflorescence ripen first, and after a while the pods of the second-order axes ripen. That is why double threshing is practiced on radish crops or desiccation is used in the middle of the yellow-green pod phase. Desiccation allows to accelerate the process of pods ripening in different locations within the inflorescence and to obtain an increase in seed yield of 0.9–1.3 c ha⁻¹ (Dorofeev, 2010).



Figure 1.50 – Morphotypes of oil radish pods



Figure 1.51 – Variation series of oil radish pods of Zhuravka variety within one inflorescence at the fruiting stage (green pod stage)



Figure 1.51a – Variable series of morphotypes of oilseed radish pods



Figure 1.51b – Variable series of morphotypes of oilseed radish pods



Figure 1.52 – Oilseed radish pod (longitudinal and transverse views) during its formation



Figure 1.53 – Oilseed radish seed in the developed “parenchymal sleeve” of the pod at the stage of waxy ripeness (magnification 200x)

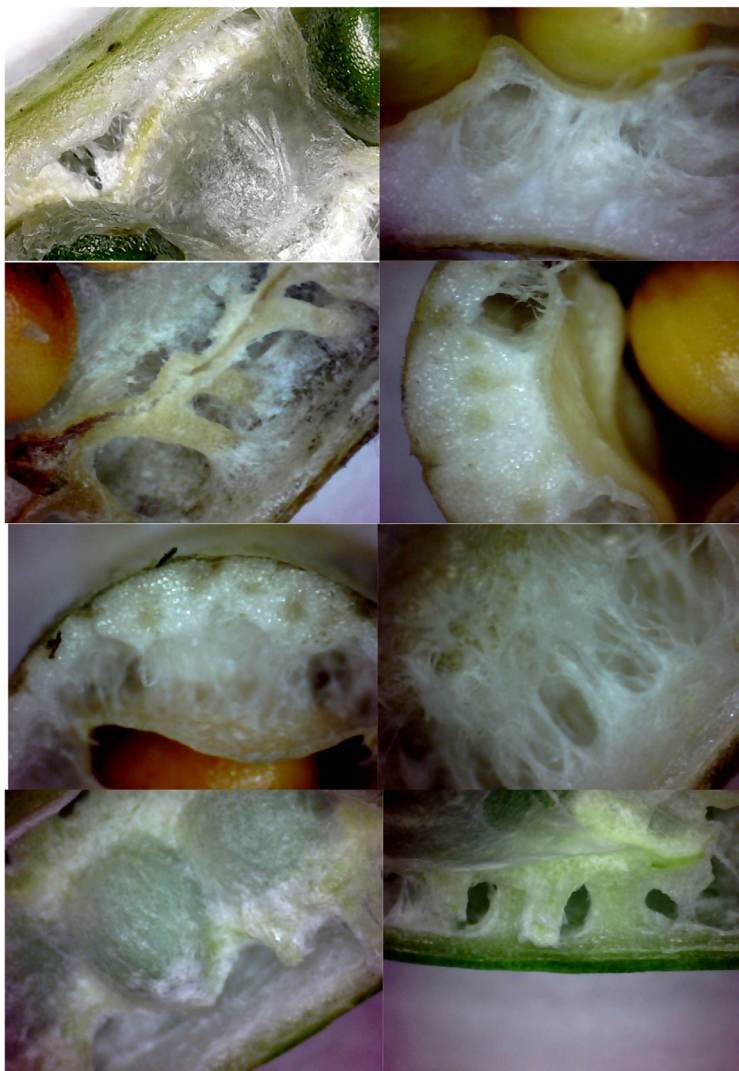


Figure 1.54a – Character of the morphological structure of the walls of the pod of oil radish variety ‘Zhuravka’ at the stage of green pod and its transverse section at the stage of milky-wax ripeness of seeds

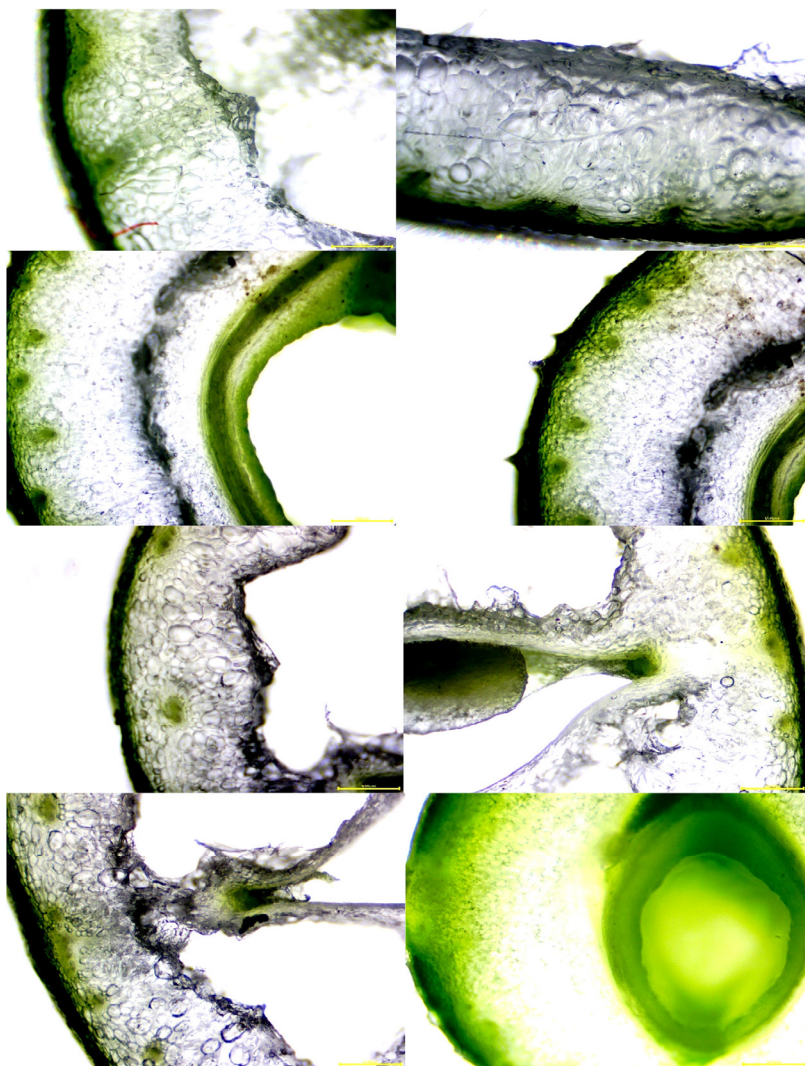


Figure 1.54b – Character of the morphological structure of the walls of the pod of oil radish variety ‘Zhuravka’ at the stage of green pod and its transverse section at the stage of milky-wax ripeness of seeds

An oilseed radish pod contains 3 to 12 seeds (Figure 1.56), which are bright brown in color (when fully ripe). The number of seeds in a pod is determined by such factors as sowing time (early sowing has higher total and individual seed productivity (Sedlyar, 1984)), as well as weather conditions during the period from budding to the beginning of flowering of the lateral branches of the second inflorescence (Krivoruchenko, 1995).



Figure 1.55 – Spatial arrangement of oilseed radish seeds in the pod



**Figure 1.56 – Variation in the number of seeds per pod
of oil radish variety 'Zhuravka'**

The weight of 1000 seeds varies widely from 7 to 13 g and depends on growing conditions and harvesting time (Sedlyar, 1984). This indicator

in oil radish has a high variability with a value for the main shoot of the inflorescence in the range of 7–13 g, lateral shoots of the second order of medium placement 6–9 g, lower placement 5–7 g. Tetraploidy increases the weight of 1000 seeds, as for example in the oil radish variety Tambovchanka, where this index is 1.5–3 g higher than in diploid varieties (Bolshov and Karabin, 1988, Figures 1.57–1.61).



Figure 1.57 – Stages of oilseed radish seed formation in ‘Zhuravka’ variety (electronic magnification 200x) (sequentially from left to right, top to bottom: seed formation: in the early milk ripeness phase; at the end of the milk ripeness phase; in the milk-wax ripeness phase; in the wax ripeness phase; in the full ripeness phase)

Oilseed radish seeds have no endosperm. The embryo (Figure 1.58) consists of two formed cotyledons with a germinal root and a growth point symmetrically located between them.

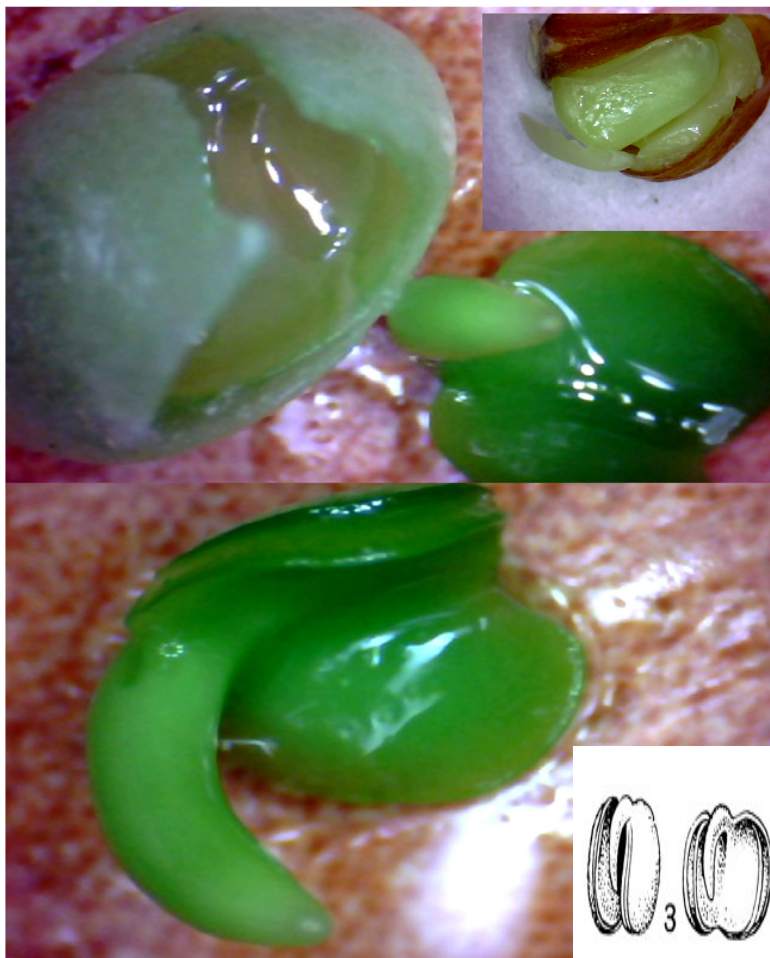
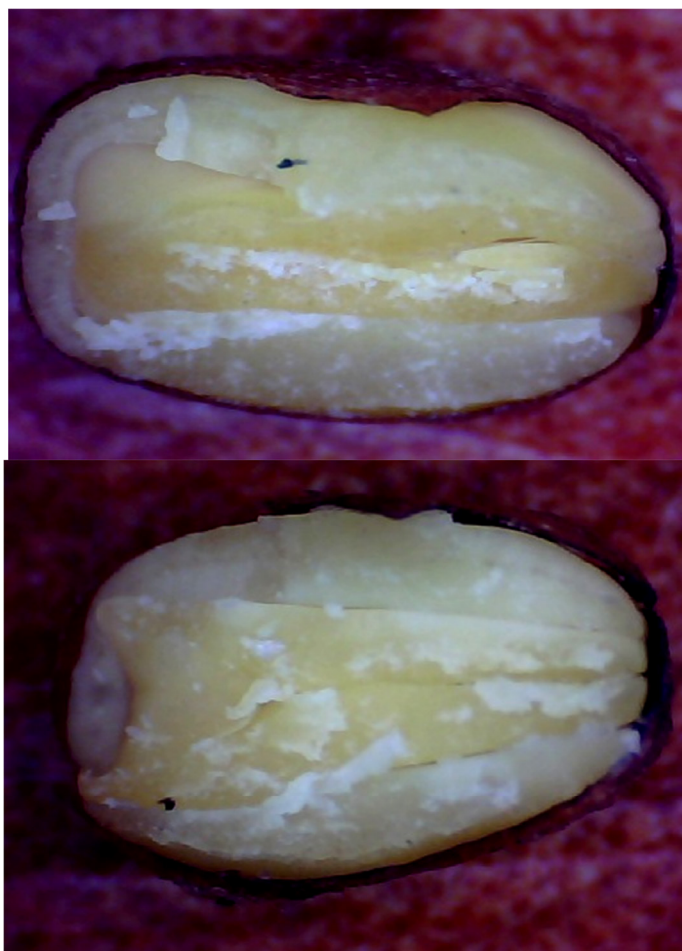


Figure 1.58 – Oilseed radish seed embryo
(type 3 of embryo root placement – folded; in the upper right corner – color of the embryo at the stage of waxy ripeness of the seed)



**Figure 1.59 – Oilseed radish seeds of Zhuravka variety
(magnification 200x)**



**Figure 1.60 – Transverse section of an oil radish seed
(top position of ‘Zhuravka’ variety,
bottom position of ‘Raduga’ variety)**



Figure 1.61 – Seed surface at milky ripeness (top position) and at full ripeness (bottom position) (300 x magnification)

1.3. Agrotechnological potential of oilseed radish

Changes in agricultural production vectors, crop structure, and new approaches to realizing the effective potential of crops require the use of highly productive fodder crops with stable adaptive properties and high feed value (Likhochvor, 2010).

Interest in less common fodder crops emerged in the late 80s of the last century. This group of crops was considered as a source of feed protein, which have a wide range of adaptive properties and can be effectively cultivated in different soil and climatic zones (Radchenko, 2009).

The presented results indicate the economic prospects and high plasticity and adaptability of oil radish as a fodder crop grown from the Arctic Circle to the arid zones of Central Asia, demonstrating high levels of both fodder and seed productivity (Figure , Tables 1.2–1.5).

Table 1.2

**Harvest of oilseed radish leaf mass and seeds
in different geographical regions for the period 1950–2014, t ha⁻¹
(summarized and grouped by Tsytisiura and Tsytisiura, 2015))**

Geographical area	Leaf and stem mass	Seeds
Poland	300–700	15–22
Germany	300–750	16–24
France	250–480	12–16
Northern regions of the USA	180–370	8–20
Lithuania, Estonia, Latvia, Belarus	300–450	9–13
Moldova	250–400	8–15
Hungary, Romania	300–450	10–20
Ukraine:		
– northern regions	300–700	10–16
– central regions	300–520	12–20
– southern regions	220–350	11–18
Kazakhstan	200–340	12–15
Uzbekistan, Tajikistan	140–200	3–7
Northern regions of the Eurasian continent	250–600	9–12.5
Extreme northern regions of the Eurasian continent	125–200	3–7
Northwestern regions of the Eurasian continent	170–310	9–12
Central regions of the Eurasian continent	400–600	5.5–10
Southern regions of the Eurasian continent	204–400	5.2–12
Far Eastern regions of the Eurasian continent	180–314	3.5–8

The first evidence of the effectiveness of oil radish use in the territory of former Russia dates back to the early nineteenth century and dates from 1802 to 1811. Some researchers emphasized the expediency of its cultivation and the possibility of industrial processing of seeds to obtain vegetable oil (Batalin, 1879).

In the review articles of Kalynovskyi in the period 1880–1892, he highly appreciated oil radish as a fodder crop with a high degree of cattle consumption. The chemical analysis of its leaf-stem mass carried out in 1893 by Schultz (one of the first) showed a content of up to 12.58% protein, 2.52% fat and 11.78% ash. Already at that time, it was recommended to use it as a green manure, especially on soils with heavy mechanical composition, and its positive effect on the yield of winter cereals and potatoes was noted (Tsytsiura and Tsytsiura, 2015).

Table 1.3

**Average annual productivity of annual fodder crops
in the Northwest region of the Eurasian continent
(average long-term data) (Kapustin, 2012)**

Cultures	Green mass yield, t ha ⁻¹	Dry matter harvest, t ha ⁻¹	Crude protein harvest, t ha ⁻¹
Corn	37.4	5.70	0.38
Sunflower	59.8	7.74	0.99
Crimson amaranth	27.4	3.47	0.49
Panicle amaranth	24.1	3.19	0.47
Fodder beans	37.3	6.10	1.20
Small mallow	28.5	5.46	0.73
Yellow lupine	18.5	2.48	0.56
White lupine	13.2	3.17	0.55
Spring rape	23.6	3.14	0.65
White mustard	25.5	4.52	0.76
Oilseed radish	27.7	5.13	0.97
Ragweed	20.3	3.61	0.68
Peas + oats (control)	24.0	4.26	0.62
LSD ₀₅	2.7	0.33	0.05

Table 1.4

**Productivity of different fodder crops
under different cultivation technologies on sod-podzolic soils
of the Non-Chernozem zone (Kapustin, 2012)**

Agricultural crops	Technology	Yield of aboveground mass, t ha⁻¹	Weight of post-harvest and root residues, t ha⁻¹ (WPR)	Above-ground mass + WPR, t ha⁻¹
White sweet clover	Extensive	2.6	3.1	5.7
	Normal	3.8	4.3	7.1
	Intensive	4.5	5.2	9.7
Meadow clover	Extensive	2.9	4.4	7.3
	Normal	4.0	4.5	8.5
	Intensive	5.1	6.1	11.2
White mustard	Extensive	2.5	2.8	5.3
	Normal	3.7	4.4	8.1
	Intensive	4.4	5.1	9.5
Oilseed radish	Extensive	4.0	5.6	9.6
	Normal	5.7	6.6	12.3
	Intensive	7.9	9.7	17.6

A valuable property of oil radish as a fodder crop is the ability to produce 1–3 mowings of flocks, which allows to obtain additional yields of leaf mass in years of sufficient moisture, and two mowings can be equivalent in productivity (Uteusch, 1991).

Today, oil radish is considered as a means of reviving the fertility of depleted soils, especially as a substitute for organic fertilizers for plowing biomass and a highly effective field phytosanitary (Shuvar, 1994).

Many sources emphasize the value of oil radish as a protein fodder crop. According to Uteusch (1991), at fodder ripeness, the aboveground mass contains (% of absolutely dry matter) 22–23% protein, 24–25% BER, including 7–8% sugars, 5–6% lipids, 25–29% fiber, and 17–18% ash. In 100 kg of weight – 16 feed units with a content of 198 g of digestible protein. However, the sugars in the radish leaf mass are in a highly insoluble form. That is why it is recommended to grow oilseed radish in mixtures with oats, corn and other crops. This crop is also valuable for the amino acid composition of the leaf mass, the quality of which is determined by hydrothermal conditions of vegetation – under dry conditions, the protein content of the green mass increases (Table 1.6).

Table 1.5
Characteristics of annual fodder grasses that are promising for cultivation in Ukraine
(Rakhmetov, 2000)

Crop	Sowing date	Seeding rate, kg ha ⁻¹	Depth of tillage, cm	Row spacing, cm	Harvesting time (rosette phase)	Yield, t ha ⁻¹	Application	Crop form
Winter melilot	August 20–30	6–8	2–3	15–30	Budding – ripening of seeds	25–30	Feed, green manure, biofuel	winter
Oilseed radish	Early spring to the second decade of August	10 – 30 depending on the method and time of sowing	2–3	15–60	Budding – ripening of seeds	25–40	Fodder, green manure, biofuel, honey plant	spring
Small mallow	From early spring to the second decade of August	3–6	2–3	45	Budding – ripening of seeds	40–60	Fodder, green manure, biofuel, honey plant	spring
Amaranthus	I - II decade of May	1	1.5–2.5	45–70	Budding – ripening of seeds	35–50	Feed, food, decorative	spring

Table 1.6

**Chemical composition of leaf and stem mass of oil radish variety
'Raduga' by stages of growth and development (Getman, 2007)**

Phases of growth	Dry matter content, %	Content in dry matter, %				
		protein	cellulose	fat	Nitrogen-free extractives	ash
The beginning of flowering	11.8	24.4	21.2	3.6	35.4	15.4
Full flowering	12.6	20.8	23.0	2.8	37.6	15.8
Beginning of pod formation	15.2	16.4	28.1	2.8	36.4	16.3

Different parts of plants differ in chemical composition (Pirie, 1972). For example, according to Werner (1983), the most valuable part of the plant is the leaf (Table 1.7), and the quality of the leaf mass is closely correlated with the leafiness of the plant. The leaves contain the bulk of ash, calcium, protein and fat (Table 1.8–1.10).

Table 1.7

**Chemical composition and nutritional value
of oilseed radish leaf mass in 1 kg (Getman, 2007)**

Mowing phase	Moisture content, %	Metabolic energy, MJ	Feed units.	Protein		Sugar, g	Fat, g	Crude fiber, g	Calcium, g	Phosphorus, g	Carotene, mg
				crude	digestible						
Clean spring sowing											
Leaf and stem mass in the phase:											
budding	88.2	1.2	0.11	21	15.7	15	6.7	31.7	2.17	0.45	21
beginning of flowering	87.3	1.25	0.12	23.6	16.3	19.7	7.22	33.6	2.28	0.49	29
end of flowering	84.6	1.39	0.14	24.1	16.6	22.1	7.01	37.9	2.22	0.50	23
In dry matter	—	8.64	0.91	158	108	146	45.5	246	14.4	3.25	252
Clean post-harvest sowing											
Beginning of flowering (per wet weight)	89.3	1.13	0.10	19.5	14.9	18	5.9	29.2	1.79	0.41	28
in dry matter	—	10.6	0.94	182	139	168	55	272	16.7	3.8	261
Full flowering (per wet weight)	86.7	1.32	0.13	21.5	16.1	21.3	7.01	36.9	2.02	0.44	25
in dry matter	—	9.92	0.98	162	121	160	52.7	277	15.2	3.33	188

Table 1.8

**Comparative chemical composition and nutritional value
of green fodder of cruciferous crops in different phases of vegetation
(Getman, 2007)**

Cultures	Contained in 1 kg of absolutely dry matter								Carotene, mg/kg of natural feed
	Feed units	Metabolic energy, MJ	Crude protein, g	Crude fat, g	Crude fiber, g	Nitrogen-free extractive substances, g	Ca, r	P, r	
Flowering phase									
Winter rape	0.92	10.67	224.6	42.4	240.5	405.7	23.0	12.5	22.69
Spring rape	1.09	11.61	196.3	58.0	188.6	455.9	21.5	13.3	38.69
Oilseed radish	0.92	10.63	200.6	52.6	242.7	389.7	25.0	10.3	30.99
Winter melilot	0.93	10.74	217.5	52.1	236.6	400.4	19.8	11.2	24.23
White mustard	1.01	11.15	245.6	41.4	213.9	402.4	26.2	10.4	39.28
Flowering phase (mass is tied up to a humidity of 70–75%)									
Winter rape	0.91	10.60	219.5	41.0	244.7	393.6	22.6	13.1	23.90
Spring rape	1.03	11.30	194.4	53.5	215.5	412.9	22.0	13.2	44.24
Oilseed radish	0.91	10.59	199.7	52.5	245.2	409.2	24.6	10.3	34.21
Winter melilot	0.84	10.20	200.2	50.1	266.4	393.0	19.2	10.5	24.95
White mustard	0.87	10.97	339.6	40.1	224.0	393.8	25.2	10.5	44.80
End of flowering – beginning of fruit formation									
Winter rape	0.86	10.28	186.3	34.2	262.0	419.4	10.5	5.3	25.43
Spring rape	0.89	10.47	196.1	41.5	251.8	409.6	19.5	7.7	35.98
Oilseed radish	0.93	10.70	180.0	48.0	239.1	451.5	19.7	4.5	28.95
Winter melilot	0.88	10.44	188.8	41.2	253.5	421.0	10.4	6.7	26.14
White mustard	0.91	10.61	193.8	46.4	244.0	419.6	12.5	8.0	35.28

Table 1.9

**Chemical composition and nutritional value of oil radish leaf mass, %
(summer sowing) (Uteusch, 1991)**

Stages of organogenesis	Crude protein	Crude fat	Crude ash	Crude fiber	Nitrogen-free extractive substances	Sugars + starch*	Feed units	Crude protein per 1 feed unit
The budding of the flower	25.9	2.3	18.5	18.2	35.1	3.34	0.87	29.7
The beginning of flowering	22.0	1.6	20.6	26.1	29.7	4.12	0.78	28.2
Full flowering	18.2	1.9	15.3	27.1	37.6	6.06	0.85	21.41
Pod formation	18.0	1.8	16.1	26.8	37.3	7.00	0.84	21.42

* This group of nutrients improves microbiological processes in the rumen, the level of volatile fatty acid formation and their percentage. The level of easily digestible carbohydrates in diets is regulated by the ratio to digestible protein. The optimal ratio of sugar to digestible protein in winter in the diets of lactating cows is in the range of 0.8–1.0:1.2 (in oil radish, this ratio is 0.25–0.50:1 with a maximum in the interphase period of full flowering – green pod). Lack of sugar in feed reduces microbial protein synthesis, negatively affects fiber digestion and carotene absorption.

Table 1.10

**Chemical composition of vegetative organs of oil radish plants
in % on absolute dry matter (Werner, 1983)**

Vegetative organs of plants	Ash	Protein	Fiber	Fat	Calcium	Phosphorus
Leaves	18.5	15.7	18.5	4.1	3.35	0.35
Stems	9.5	10.3	30.9	2.0	0.83	0.38
Pods	6.2	13.7	17.1	2.9	0.71	0.46

In addition, oil radish seeds are valuable for their protein content (Table 1.11–1.12).

During the growing season, the chromic composition of plants changes (Samokhin, 1976): At the beginning of flowering, the protein content in the leaf mass of oilseed radish reached 24.44 %, and at the end of the growing season it decreased to 11.44 %. The ash content of its mass in the budding phase was 24.15 %, by the beginning of mass flowering it decreased to 17.3–18.31 %, and during the fruiting period – 16.7–17.8 %. According to

CHAPTER 1

various estimates, 100 kg of its leaf-stem mass contains from 12 to 18 k.o., which accounts for 120–220 g of digestible protein.

Table 1.11

Crude protein content and yield from seeds of spring oilseeds depending on species characteristics (Kozlenko, 2011)

Crops	Protein content, %.	Protein yield, kg ha ⁻¹
Spring rape	20.69	562.11
Spring melilot	18.52	298.12
White mustard	24.35	625.68
Grey mustard	23.91	530.75
Oilseed radish	21.28	427.73
Spring camelina	25.00	575.72
Safflowe	11.10	207.21
Oil flax	22.81	536.81

Table 1.12

Amino acid composition of leaf and stem mass of oil radish on an unfertilized background depending on the regime of vegetation moisture (Werner, 1983)

Amino acid	Content in absolutely dry matter	
	in relatively dry years	into normal moisture content
Lysine	1.17 – 1.36	0.75 – 0.92
Histidine	0.43 – 0.57	0.26 – 0.33
Arginine	0.84 – 0.92	0.60 – 0.74
Asparagine	1.66 – 1.72	1.14 – 1.32
Threonine	0.81 – 0.94	0.61 – 0.74
Serine	0.83 – 0.95	0.58 – 0.72
Glutamine	2.41 – 2.75	1.91 – 2.15
Glycine	0.78 – 0.86	0.61 – 0.72
Valine	0.97 – 1.12	0.73 – 0.86
Isoleucine	0.72 – 0.81	0.46 – 0.58
Leucine	1.39 – 1.48	0.94 – 1.16
Tyrosine	0.61 – 0.81	0.40 – 0.55
Phenylalanine	0.88 – 0.97	0.63 – 0.78
Alanine	0.90 – 1.03	0.71 – 0.82

In the studies of T. D. Mosin (1989) it was found that the growth of dry matter in oil radish continues steadily for 20-30 days after the onset of the flowering phase. At the same time, the fodder value of oil radish leaf mass had maximum values in the period of the beginning of flowering – full flowering, but there was a steady tendency to decrease the provision of a feed unit with digestible protein (Tables 1.13–1.14). Based on these statements, the mowing maturity of oil radish is considered in the plane of the beginning of flowering – the beginning of fruiting to maintain a positive combination of chemical composition and yield of leaf mass.

Table 1.13

**Dependence of the quality of oilseed radish leaf mass
on the harvesting time (Mukhina, 1980)**

Harvesting period	Dry matter, %	Content per 1 kg of absolutely dry matter				Provision 1 k. unit of digestible protein, g
		phosphorus, g	potassium, g	calcium, g	feed units, kg	
The beginning of flowering	9.4	4.62	48.1	25.1	0.86	276
Full flowering	11.4	3.49	37.3	22.0	0.83	234
The beginning of fruiting	11.9	3.33	32.4	20.0	0.83	209
The middle of fruiting	13.9	2.41	28.6	18.8	0.83	181
End of fruiting	15.4	2.68	32.0	18.7	0.80	167

According to Bakhmat (1993), 1 kg of dry matter of oil radish contains up to 50 g of sugars (146–160 g according to Podobed (2009)), which allows the crop to be used as a lactic fodder. Moreover, Shlapunov (1987) noted that the sugar content in the leaf mass tends to increase from 7–12 % in the budding phase to 13–16 % in the fruiting phase and 16–19 % in the seed ripening phase, which plays a role in determining the optimal phase for silage crops – the phase of the beginning of fruiting. The leaf mass of oil radish is also rich in potassium, calcium, trace elements and vitamins. The content of copper is 2.2–2.5 mg per 1 kg of absolutely dry matter, zinc 20–35 mg, manganese 20–40, molybdenum 0.3, cobalt 0.10 mg (Bitov, 2001). The content of ascorbic acid in the budding phase per 100 g of dry matter is 70–80 mg (1000–1050 g per 100 g of dry matter), and

during the fruiting period, respectively, 63 and 525. The carotene content ranges from 4 to 5 mg per 100 g of dry matter (Podobed, 2009). In the research of the Department of Agriculture (during two rotations of four-field grain and fallow crop rotation, 1996–2003), oil radish was grown in occupied pairs for fodder, and in green manure pairs it was used as a green fertilizer. According to the results of chemical analysis of its leaf mass, it was found that during the flowering period, 1 kg of green mass of oil radish contains (in terms of dry matter) 19.7 crude protein, 3.0 fat, 18.04 ash, 1.95 calcium and 0.33 phosphorus. The culture is characterized by a high content of macro- and microelements (Table 1.15).

Table 1.14

Protein value of oil radish leaf mass depending on the harvesting period, in % on absolutely dry matter (Shlapunov, 1987)

Budding		Full flowering		Fruiting		Wax ripeness of seeds	
crude protein	pure protein	crude protein	pure protein	crude protein	pure protein	crude protein	pure protein
26.4 – 28.9	20 – 23.7	15.4 – 21.7	14.2 – 15.9	14.1 – 15.0	12.1 – 13.4	12.1 – 12.7	7.7 – 10.6*

* – range of values within the annual fluctuations of the indicator.

Table 1.15

Chemical composition of oil radish leaf mass by content of of macro- and microelements (Concept of the targeted comprehensive research program of the National Academy of Sciences of Ukraine, 2018)

Indicator	Content
Macroelementi, g kg⁻¹	
Potassium	14.50
Sodium	0.90
Magnesium	2.09
Sulfur	6.02
Chlorine	4.00
Trace elements, mg kg⁻¹	
Iron	149.8
Manganese	62.0
Copper	6.0
Zinc	36.0
Cobalt	0.90

Today, in European countries, oil radish is firmly established as a component of the fodder crop group in Poland, Germany (mainly East Prussia, Neumark), the Southern part of Great Britain, South-Eastern Romania, the Czech Republic and Slovakia, and even in Spain. In these countries, oil radish is mainly grown together with seradella and other legumes for fodder and as the main component in organic farming and production of environmentally friendly products (Tsytisiura, 2013). Another direction of its use has clearly emerged to produce vegetable oil, which is used for biofuel production and is close to rapeseed oil in a number of characteristics (Tsytisiura and Tsytisiura, 2011). In European countries, this area is actively developed by Germany, Poland, and the UK, where varieties with high oil content in seeds are being created. It should also be noted that oil radish forms a large phytomass, which in turn can be used as green manure and for fermentation to produce biogas. Between 2000 and 2020, its area in Europe and the United States (northern states) almost tripled compared to 1990. In particular, the Landkom company is actively engaged in growing oil radish in Europe and South Africa. In the United States, the center for the study of vegetable oil from radish is the state of Georgia (UGA College of Agricultural and Environmental Sciences). The research of scientists at this institution notes that oil radish is an extremely promising non-food crop for the production of alternative fuels. The seeds of this crop contain 40–45% of vegetable oil, which is similar in chemical composition to rapeseed oil and has a wide range of economic uses, which in turn makes it an excellent candidate for the biodiesel market (Sharon, 2020). Thus, Shpaar (1999) notes that the technical direction of its oil use is determined by the content of simple unsaturated fatty acids (in % of the total fatty acid content – aicosene (8–11%) oleic (23–36 %), erucic (9–30 %)), high content of saturated oleic acid (4–6 %), low content of multiple unsaturated linoleic (10–18 %) and linolenic (11–17 %) fatty acids. However, the high content of glucosinolates up to 160–180 $\mu\text{mol/g}$ makes it difficult to use oil radish cake and oil in animal feeding.

It should be noted that in Ukraine, at present, industrial processing of oil radish according to the “pressing – extraction” scheme for the production of technical oil is complicated by the lack of regulatory and technical documentation (DSTU, TU, etc.) for oil and meal made from it.

It should not be forgotten that oil radish is a good honey plant with a multi-term use from June to September. The productivity of honey harvesting is 50-70 kg/ha (Tsytsiura and Tsytsiura, 2015).

It is widely used in biological and organic farming systems. The crop is used as a biological ameliorator in crop rotations with potatoes to increase soil organic matter supply and reduce weed infestation of field crops of a wide range of uses (Tsytsiura and Tsytsiura, 2015).

According to Likhochvor (2008), to control the number of nematodes in the links of crop rotations where sugar beets and rapeseed are grown, it is important to grow nematode-resistant varieties of oil radish both in the main crop and in post-harvest crops. The author notes that oil radish varieties have been created that are suitable for biological destruction of the nematode in the soil. These are varieties of foreign selection Colonel, Pegletta, Matador and domestic selection Zhuravka. These varieties can be used as intermediate provocative crops. Polish researchers (Nowakowski, 1996) found that the reduction in the number of nematodes in the cultivation of nematode-resistant radish varieties in post-harvest crops is 30–50%, namely in the Kolonel variety – 46%, Remonta – 42%, Adagio – 40%.

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