CONCLUSION

Summarizing the multifaceted portfolio of olive radish in the system of its multipurpose use for the rehabilitation of degraded soils and lands on the principles of climate neutrality, the main results should be noted:

1. According to the results of a multi-year study cycle, oil radish showed high productivity and adaptability. This is confirmed by the average indicators of its long-term productive and biochemical portfolio, which for the spring sowing period had the following parameters: formed aboveground biomass (BM) 24.04 t ha-1, formed root biomass (RBM) 8.7 t ha^{-1}, soil coverage at 70 days after sowing (GC70) 73.77%, crude protein content (CP) 15.56% $_{DM}$, crude fat (CF) 3.98% $_{DM}$, cellulose 21.73% $_{DM}$, hemicellulose 10.95% $_{DM}$, phosphorus 0.62% DM, potassium 3.63%$_{DM}$, calcium 0. 96%$_{DM}$, sulfur 0.42%$_{DM}$, glucosinolates (GSL) 13.57 μmol $g^{-1}{}_{DM}$, C/N ratio 16.02, Residue quality (RQ) 84.99%$_{DM}$, Carbohydrates (CH) 67.08%$_{DM}$, GSL productivity 41.2 mol ha^{-1}. For the summer sowing period, similar parameters were as follows: BM 18.34 t ha^{-1}, RBM 5.50 t ha^{-1}, GC70 50.74%, CP 19.16%$_{DM}$, SF 4.61%$_{DM}$, cellulose 24.43 %$_{DM}$, hemicellulose 12.85%$_{DM}$, phosphorus 0.63%$_{DM}$, potassium 3.96%$_{DM}$, calcium 1.01%$_{DM}$, sulfur 0.48%$_{DM}$, GSL 19.70 μmol $g^{-1}{}_{DM}$, C/N ratio 13.30, Residue quality (RQ) 81.03%$_{DM}$, CH 61.93%$_{DM}$, GSL productivity 54.90 mol ha^{-1}. Using the above data block with the application of Multi-criteria decision aiding (MCDA), the possibility of multi-purpose use of oil radish in the criterion system of multi-service cover crop (MSCC) was proved in the following order of decreasing technological significance for the conditions of unstable hydrothermal regime of its vegetation period on soils with an average level of soil fertility potential (averaged for both sowing dates): 'Green manure' – 'Fodder' – 'Cover crop' – 'Biogas' – 'Catch crop'.

2. Oilseed radish was sensitive to water extracts of 23 perennial weed species tested in the range of concentrations of 0.25–16.0% (w/v). The range growth of weed species allelopathic potential on their impact on seed germination according to APG averaged for two variants of germination was as follows: *Cuscuta campestris* Yuncker (APG (average for germination variants) 0.68) > *Acroptilon repens* (L.) de Candolle (0.66) > *Plantago major* L. (0.63) > *Linaria vulgaris* Mill. (0.61) > *Equisetum arvense* L. (0.60) > *Cirsium arvense* (L.)

Scopoli, *Convolvulus arvensis* L. (0.59) > *Agropyron repens* (L.) Gould (0.58) > *Onopordum acanthium* L. (0.57) > *Cyclachaena xanthiifolia* Nuttall (0.55) > *Sonchus arvensis* L., *Cichorium intybus* L., *Plantago lanceolata* L. (0.54) > *Artemisia absinthium* L. (0.51) > *Echium vulgare* L., *Rumex acetosella* L. (0.48) > *Artemisia vulgaris* L. (0.47) > *Arctium lappa* L. (0.46) > *Cynodon dactylon* (L.) Pers., *Rumex confertus* Willdenow (0.44) > *Carduus acanthoides* L., *Taraxacum officinale* Weber (0.39) > *Achillea millefolium* L. (0.36). It has been established that "speed of germination" and "coefficient of velocity of germination" can be used as effective indicators for assessing the allelopathic sensitivity of test objects. Thus, they were respectively 5–7 germinated seeds per day for the percentage of germinated seeds for 7–9 days over 30% of the total number laid for germination, and for species with weak allelopathic activity, respectively, 10–11 germinated seeds per day of germination and the percentage of germinated seeds per 7–9 days more than 4–15% of the total in the case of oilseed radish in allelopathically adhesive species at an extract concentration of 4.0%. Taking into account the classification of allelopathic potential (Smith, 2013) with 47.8% of the researched species belonging to the Non-allelopathic (NA) class and the absence of weeds belonging to the class Highly allelopathic (HA) for the test object, radish oilseed should be considered as an effective candidate for its application in the system of weeds biological control of sidereal and mediator application in traditional rotational schemes of cultivation of major crops of the non-cruciferous group.

3. Oilseed radish was very sensitive to the water extracts of the 54 weed species tested in the range of concentrations 0.25–16% (w v^{-1}). Soil alleviated the allelopathic impact of the weed extracts. APG indexes allowed to cluster weed extracts in 10 intervals of 0.05 included in the range 0.26–0.72. Twenty seven species (50.0% of the total tested) had APG values higher than 0.50. The APG values calculated from data recorded from Petri dish and soil bioassays allow to classify the weed species from more to less harmful on oilseed radish, in the following order: *Raphanus sativus* L. var. *oleiformis* Pers. (0.68–0.72) > *Amaranthus retroflexus* L. (0.64–0.67) > *Chenopodium album* L. (0.63–0.67) > *Raphanus raphanistrum* L. (0.63–0.67) > *Papaver rhoeas* L. (0.61–0.68) > *Brassica campestris* (L.) Janchen (0.60–0.67) > *Brassica napus* L. (0.60–0.67) > *Sinapis arvensis* L. (0.62–0.64) >

Sinapis alba L. (0.59–0.62) > *Fumaria officinalis* L. (0.60–0.62) > *Galinsoga parviflora* Cavanilles (0.57–0.62) > *Tripleurospermum maritimum* (L.) Koch (0.57–0.61) > *Portulaca oleracea* L. (0.57–0.60) > *Rocket-cress* Brown (0.56–0.59) > *Lepidium draba* L. (AP = 0.54–0.57) > *Brassica napus* L. (0.53–0.57) > *Sisymbrium loeselii* L. (0.54–0.57) > *Chondrilla juncea* L. (0.52–0.55) > *Galium aparine* L. (0.49–0.58) > *Echinochloa crus-galli* (L.) P.Beauv. (0.47–0.57) > *Senecio vernalis* (Waldstein & Kitaibel) Alexander (0.50–0.52) > *Solanum nigrum* L. (0.54–0.55) > *Descurainia sophia* (L.) Prantl (0.49–0.53) > *Thlaspi arvense* L. (0.46–0.52). The weeds were classified according to their APSG and APRG indexes, and the percentage of appearance frequency (F) in oilseed radish fields, from more to less harmful, as: *Amaranthus retroflexus* (0.48, 0.64, 62.33–71.67) > *Echinochloa crus-galli* (L.) P.Beauv (0.41, 0.65, 58.67–71.67%) > *Setaria glauca* L. (0.53, 0.61, 56.00–62.33%) > *Chenopodium album* L. (0.55, 0.47, 42.67–54.00%) > *Brassica napus* L. (0.60, 0.67, 5.00–53.50%) > *Galinsoga parviflora* Cavanilles (0.63, 0.37, 25.00–46.33%) > *Sinapis alba* L. (0.60, 0.64, 4.30–42.80%) > *Tripleurospermum maritimum* (L.) Koch (0.41, 0.49, 16.33–42.67%) > *Raphanus sativus* L. var. *oleiformis* Pers. (0.65, 0.58, 3.50–40.70%) > *Polygonum lapathif*olium (L.) Delarbre (0.48, 0.36, 24.67–34.33%) > *Setaria viridis* (L.) Palisot de Beauvois (0.41, 0.35, 16.67–25.00%) > *Rocket-cress* Brown (0.56, 0.50, 6.67–22.67%) > *Brassica campestris* (L.) Janchen (0.47, 0.61, 19.33–22.33%) > *Lactuca serriola* L. (0.56, 0.57, 10.67–21.67%) > *Thlaspi arvense* L. (0.38, 0.64, 7.67–21.0%) > *Senecio vernalis* (Waldstein & Kitaibel) Alexander (0.65, 0.58, 11.00– 17.67%) > *Lepidium draba* L. (0.57, 0.71, 7.11–8.92%). Considering the obtained allelopathic potential for different types of weeds, the maximum harmfulness of weed cenosis in the oilseed radish agrophytocoenosises will be noted if there were 30% of weeds with APG (APRG, APSG) level 0.5 in case of young-soboliferous-rhizomatous type of infestation. This was confirmed by the results of regression analysis with the level of multiple regression coefficient (R) in the range of 0.555–0.688 ($p < 0.05$) in the system of comparing the frequency of appearance (F) (the resulting trait) and the studied types of allopathic potential (APG (Petri dish bioassays), APG (Soil bioassays), APRG, APSG).

4. Oilseed radish as a multidisciplinary bioenergy crop has demonstrated high biogas and biomethane potential with the possibility of long-term use and biomass harvesting in a wide range of phenological phases.From the point of view of the potential share of methane yield in combination with biogas productivity for the phenological phase of budding (BBCH 50–53) and flowering (BBCH 64–67) with the subsequent process of silage fermentation, the variant of the first sowing term with the level of biochemical methane potential (BMPGomp), respectively, 304.94 and 344.13 LN kg^{-1}_{ODM}, specific methane yield (SMY) 296.91 and 319.66 LN kg^{-1}_{ODM} with a maximum specific methane production rate (R_m) 27.88 and 33.74 LN kg^{-1}_{ODM} d^{-1} . For the phenological phase of the green pod (BBCH 73–75), the variant of the fourth sowing term (summer term as a possible option for intermediate cultivation of oilseed radish in crop rotation) with the corresponding parameters was determined as expedient: BMPGomp 287.26 LN kg^{-1}_{ODM}, SMY 283.18 LN kg^{-1}_{ODM} at R_m 29.46 LN $kg^{-1}_{ODM}d^{-1}$. The optimal biochemical idiotype of oilseed radish plants was determined in the system of pairwise correlation and multiple regression comparison from the point of view of realization of biomethane potential of the crop when harvesting its biomass in the interphase period of budding–green pod (BBCH 50–75): CP 14–18%DM, CFb 16–20%DM, CA 14–18%DM, CF 3.1–3.2%DM, NfE 48–50%DM at a C/N ratio of 20–22 with the acidity of the subsequent silage-fermented mass at the level of pH 4.6–5.0.

5. Based on comparison of the oil from the seeds of oilseed radish varieties of different breeding, both in terms of the fatty acid composition and its physical and physicochemical properties, this crop should be considered as one of the promising ones for use in the production of multicomponent biofuels. Oil from these varieties, on average, is characterized by a high content of monounsaturated fatty acids (59.69%), especially the highest value of oleic acid (18:1; 33.87%). PU/MU was rather lower – 0.479–0.545 – so the oxidative stability of this oil is high. The other fatty acid ratios (DR – 0.326–0.349, ER – 0.257–0.306, ODR – 0.446–0.487, LDR – 0.418–0.473, S/U – 0.099–0.132) indicate a wide range of potential biofuel use for the oil of this plant species. Particularly valuable in this regard were the varieties 'Sabina' and 'Nika' with the highest values of oleic acid (18:1; 34.62–34.97%) and an S/U ratio of 0.099–0.102.

The possibility of successful use of oil from oilseed radish is also confirmed on the basis of a comparative analysis of its basic properties with those of other oils common in biofuel production. Among the valuable features are a low level of carbon residue (0.31 wt.%) and low sulphur content (0.0017 wt.%), a high calorific value (37.93 MJ kg^{-1}) and preservation of the main physical and physicochemical parameters of the oil during hightemperature flow (polymerization), especially against the background of its oxypolymerization. The last factor confirms the possibility of successful use of this oil in closed engine systems. However, the low freezing point, high flash point and higher viscosity values are reasons to recommend its use as a component of mixed biofuels. This direction needs additional scientific study.

6. The potential of oil radish in terms of soil rehabilitation and soil restoration in Ukraine is not fully utilized, which requires the inclusion of oil radish as a component of bioorganic, green manure, phytoremediation, phytoremediation and bioenergy technologies in areas subject to anthropogenic and agroecological degradation of soil cover of varying degrees.

7. Oilseed radish should also be considered as a valuable component of agrobiocenoses of territories, providing both a positive balance of nutrients in soils due to natural processes of biorecycling of its biomass and a commodity of the honey and herbal medicine base, which occupies an important ecological niche in the biogeocenosis of many territories and countries.