Scientific Papers. Series A. Agronomy, Vol. LXVII, No. 1, 2024
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

INFLUENCE OF IRRIGATION METHODS AND REGIMES ON SESAME SEED YIELD

Vira KONOVALOVA[1], Volodymyr KONOVALOV[2], Andrii TYSHCHENKO[1], Olena TYSHCHENKO[1], Viktor SHARII[1], Kateryna FUNDIRAT[1], Serhii ROI[1], Nadiia REZNYCHENKO[1]

[1]Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine, 24 Mayatska doroga Street, sett. Khlybodarske, Odesa District, Odesa Region, 67667, Ukraine
[2]Askanian State Agricultural Research Station of the Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine, Tavrichanka village, Kakhovka District, Kherson Region, 74862, Ukraine

Corresponding author email: tischenko_andriy@ukr.net

Abstract

The purpose of the study was to establish the effect of different methods (sprinkling, surface and subsoil drip irrigation) and different soil moisture content (HB) (70-75% HB, 75-80% HB and 80-85% HB) on water consumption and seed yield of sesame plants. The research was conducted in the semi-arid climatic zone of the Southern Steppe of Ukraine. In these studies, the best method of irrigation and the optimal level of soil moisture for sesame plants were established. The seed productivity of sesame and the elements of the yield structure under different methods and soil moisture levels were established, as well as the indicator of water use efficiency was determined.

***Key words**: sesame, irrigation, sprinkling, drip irrigation, total water consumption, yield, water use efficiency.*

INTRODUCTION

Sesame (*Sesamum indicum* L.) (2n = 26) is one of the oldest and early-ripening oil crops in the world. Belongs to the order Tubiflorae, family Pedaliaceae, genus Sesamum, and is the most commonly cultivated oilseed species among more than 30 species in this genus (Zhang et al., 2013). Predominantly considered a self-pollinating plant, although a low percentage of cross-pollination has been reported (Ashri, 2007; Konovalova et al., 2023a).

The world's cultivated area of sesame is about 10.5 million hectares with an annual production volume of about 6.0 million tons (Sharaby & Butovchenko, 2019). The average yield ranges from 300 to 500 kg/ha, but with proper care and the use of modern agricultural technologies, it can reach 3000 kg/ha (Abadi, 2018). The world's leading countries in sesame production are India, Myanmar, China, Sudan, Tanzania, Ethiopia, Uganda and Nigeria. Japan is the largest importer of sesame in the world due to sesame oil being an important ingredient in Japanese food, followed by China, which is the second largest importer of sesame in the world, although it is one of the largest producers of sesame seeds. In addition, there are many other major sesame importing countries such as USA, Netherlands, Turkey, Canada as well as France. Recently, the consumption of sesame seed products and oil has been steadily increasing both in Europe and in the United States (Abate, 2015).

Sesame is widely known as the king of oil crops due to the high oil content of the seed (50-63%), 17-32% protein (rich in sulfur containing amino acids), and 80% of sesame oil consists of unsaturated fatty acids (Eskandari et al., 2015), it is grown for food, medicinal purposes or used for biodiesel production (De Lima et al., 2020). The seeds have high stability and resistance to rancidity, and are used to make pasta, candies, pies, paints, soaps, cosmetics, and medicines, as well as ingredients for breads, chips, and health foods (Dias et al., 2017). Sesame has high therapeutic and nutritional value (Anastasi et al., 2017) and has been recognized as a good source of high-quality oil with a high proportion of unsaturated fatty acids, proteins and antioxidants (Bahrami et al., 2012). In addition, sesame seeds are rich in minerals (calcium, iron, phosphorus) and vitamins (vitamin A, thiamin and riboflavin). Due to its high quality, sesame is also called the "queen of oil crops" (Deepthi et al., 2014). Sesame oil is highly valued for its nutritional value associated with health benefits, and the quality index (ratio of unsaturated fatty acids to saturated fatty acids) for edible oil in sesame varies from 83-87% in the seed (Wei et al., 2015; Eskandari et al., 2015).

Consumption of seeds or oil has been reported to have numerous pharmacological properties such as lowering blood lipids and arachidonic acid levels, lowering cholesterol (Visavadiya & Narasimhacharya, 2008), providing anti-proliferative activity (Yokota et al., 2007) and anti-inflammatory function (Hsu et al., 2005), increasing fatty acid oxidation enzymes in the liver, showing antihypertensive (Nakano et al., 2008) and neuroprotective effects against hypoxia or brain damage (Cheng et al., 2006). Currently, sesamin is the most potent food known to effectively improve the bioavailability of γ-tocopherol (Cooney et al., 2001). Such characteristics have expanded the use of sesame in antiseptics, bactericides, functional food products, pharmaceutical and cosmetic preparations (Namiki, 2007).

Sesame is a drought-resistant crop (Tewelde, 2019). Studies conducted on sesame in different countries have shown that it prefers fairly high temperatures and limited soil moisture to obtain satisfactory yields (Bahrami et al., 2012; Konovalova et al., 2023b).

However, in recent decades, climate changes have been observed, the so-called "global warming", as a result of which the temperature regime is increasing, dry periods are becoming more frequent and their duration is increasing (Vozhehova et al., 2022b; Tyshchenko et al., 2020b). This significantly affects the amount of precipitation and its redistribution during the growing season and is one of the main abiotic stress factors, which leads to a significant decrease in the yield of agricultural crops (Tyshchenko et al., 2020a; Vozhehova et al., 2021a; Lavrynenko et al., 2023).

Sesame is very sensitive to environmental conditions and abiotic factors such as temperature and soil moisture, especially excess moisture (Ucan et al., 2007). Alizadeh (Meena & Rao, 2015) reported that sesame is sensitive to water deficit at seedling, flowering and seed filling stages, resulting in yield loss. Sesame is usually grown as a dryland crop, but it responds well to irrigation and is well suited as an alternative crop to irrigation as it has a low crop water requirement (Pabuayon et al., 2019). Therefore, it is believed that with the help of irrigation, a significant increase in its yield can be obtained (Uçan et al., 2007).

The purpose of the work. To investigate the effect of different methods and regimes of irrigation on water consumption and seed productivity of sesame plants.

MATERIALS AND METHODS

The research was conducted during 2019-2021 at the experimental field of the Askanian State Agricultural Research Station, (46°33'12"N; 33°49'13"E; 39 m above sea level) of the Institute of Climate-Smart Agriculture of the National Academy of Agrarian Sciences of Ukraine. In terms of soil and climate, it is located in the steppe zone, on the Kakhovsky irrigated massif.

The method of establishing a field experiment is split plots. Main areas (factor A) – irrigation methods (sprinkling, surface and subsoil drip irrigation); sub-sites (factor B) – irrigation regimes (70-75% HB (HB - the lowest moisture capacity), 75-80% HB and 80-85% HB). Sesame variety Husar. Wide-row sowing with 70 cm between rows. The area of the sowing area is 60 m^2, the area of the accounting area is 50 m^2, repetition three times. Soil moisture was determined by the thermostatic weight method (Alpatiev, 1981). Water use efficiency (WUE) was determined according to Allen et al. (Allen et al., 2006).

Statistical processing of experimental data was carried out by AgroSTAT, XLSTAT, Statistica (v. 13).

RESULTS AND DISCUSSIONS

The research data made it possible to establish the effectiveness of different methods and regimes of irrigation on the productivity of sesame plants.

Under conditions of natural moisture, the total water consumption (E) was 4490 m^3/ha. It was the largest at 5160 m^3/ha for irrigation and maintenance of the irrigation threshold at the level of 80-85% HB. The smallest – 4,497 m^3/ha on subsoil drip irrigation and maintenance of the irrigation threshold at the level of 70-75% of HB (Table 1).

Table 1. Water consumption by sesame plants depending on irrigation methods and soil moisture levels

Irrigation methods (A)	Irrigation regimes (B)	Moisture reserves at the beginning of the growing season, m^3/ha	Moisture reserves at the end of the growing season, m^3/ha	Precipitation, m^3/ha	Irrigation rate, m^3/ha	Total water consumption (E), m^3/ha	Water use efficiency (WUE), kg/m^3
Natural moisturizing (control)		1450	480	3520	0	4490	0.12
Sprinkling	80-85% HB	1479	739	3520	900	5160	0.15
	75-80% HB	1479	702	3520	750	5047	0.19
	70-75% HB	1479	673	3520	450	4776	0.17
Surface drip irrigation	80-85% HB	1461	583	3520	450	4848	0.20
	75-80% HB	1461	552	3520	330	4759	0.24
	70-75% HB	1461	517	3520	240	4704	0.24
Subsoil drip irrigation	80-85% HB	1421	703	3520	420	4658	0.19
	75-80% HB	1421	667	3520	300	4574	0.23
	70-75% HB	1421	654	3520	210	4497	0.22

Sesame irrigation methods and regimes had an effect on the height of sesame plants. Sesame plants were characterized by the lowest height of 104 cm under conditions of natural moisture. The tallest plants were 135-143 cm under surface drip irrigation, and under sprinkler and subsoil drip irrigation their height was 119-134 and 119-122 cm, respectively (Table 2).

The largest number of pods, 89 pcs. per plant, and the number of seeds, 5518 pcs. With surface drip irrigation and soil moisture at the level of 75-80% HB, the number of pods was 85 pieces per plant and the number of seeds was 4416 pieces/plant, with a weight of 1000 seeds of 3.11 g. While with subsoil drip irrigation and soil moisture at the level of 75-80% HB, the weight of 1000 seeds was 2.82 g.

Our research results are consistent with the findings of Nadeem et al. and Ekom D. C. T. et al. (Nadeem et al., 2015; Ekom et al., 2019), who reported that the number of capsules per plant in sesame plants was significantly affected by different levels of soil moisture regimes. The maximum number of pods per plant was observed at the optimal level of soil moisture, and the minimum number of pods per plant was obtained at a moisture deficit of 75% and an excess of moisture of 25%.

The lowest yield of sesame seeds was 530 kg/ha under conditions of natural moisture. On average, according to the methods of irrigation, the yield of sesame seeds was: with sprinkling - 840 kg/ha, surface and subsoil drip irrigation 1070 and 982 kg/ha, respectively.

Under irrigation, the highest yield was 950 kg/ha with soil moisture at the level of 75-80% RH. Under surface and subsoil drip irrigation, the highest yield of 1160 and 1060 kg/ha, respectively, was at a soil moisture level of 75-80% HB.

Table 2. Influence of irrigation methods and soil moisture levels on structural elements and yield of sesame seeds

Irrigation methods (A)	Irrigation regimes (B)	Plant height (h), cm	Number of pods on 1 plant (n), pcs.	Number of seeds per 1 plant (n_s), pcs.	Weight of seeds from 1 plant, g	Weight of 1000 seeds ($m1_{000}$), g	Yield (Y), kg/ha	Average yield by irrigation regimes, kg/ha
Natural moisturizing (control)		104	53	3281	8.83	2.69	530	530
Sprinkling	80-85% HB	134	62	3744	10.52	2.81	780	872
	75-80% HB	123	64	4096	11.88	2.90	950	1057
	70-75% HB	119	61	3904	11.05	2.83	810	977
	Average	125	62	3915	11.16	2.85	840	–
Surface drip irrigation	80-85% HB	135	73	3650	11.13	3.05	950	
	75-80% HB	143	85	4416	13.73	3.11	1160	
	70-75% HB	141	82	3910	12.00	3.07	1120	
	Average	140	80	3992	12.30	3.08	1070	
Subsoil drip irrigation	80-85% HB	122	60	4420	12.07	2.73	885	
	75-80% HB	119	89	5518	15.56	2.82	1060	
	70-75% HB	119	78	4836	13.30	2.75	1000	
	Average	120	76	4691	13.13	2.80	982	
LSD_{05}	A	3.12	1.61	22.85	0.16	0.44	9.2	
LSD_{05}	B	1.24	0.48	12.84	0.09	0.23	7.6	

Research conducted by Mekonnen S.A. & Sintayehu A. indicate that the highest yield (1840 kg/ha) was obtained with optimal irrigation (75% ETc), while increasing the moisture deficit to 50% resulted in the lowest yield (670 kg/ha) (Mekonnen & Sintayehu, 2020). Similar research data was obtained by Hailu E. K. et al., which show that with 100% ETc the yield was 991.17 kg/ha, 75% ETc – 1024.79 and 50% ETc – 990.16 kg/ha (Hailu et al., 2018). Research by Ahmed E. N. M. & Mahmoud F. A. shows that a total water consumption of sesame plants of 650 mm had the highest water use efficiency with a seed yield of 3.6 t/ha. Increasing the total water consumption to 750 mm increased seed yield to 3.8 t/ha, but the coefficient of water use efficiency decreased. Reducing the total water consumption to 550 mm reduced the yield by almost 2 times (Ahmed & Mahmoud, 2010).

In our studies, under conditions of natural moisturizing, the water use efficiency (WUE) was 0.12 kg/m^3. For different irrigation methods, the most effective use of water was based on soil moisture level and was 0.19 kg/m^3 (for a total water consumption of 5047 m^3/ha) during sprinkling and 0.23 kg/m^3 (4574 m^3/ha) for subsoil drip irrigation. On surface drip irrigation, this indicator was the highest at soil moisture levels of 75-80% HB and 70–75% HB and was 0.24 kg/m^3 (with a total water consumption of 4759 and 4704 m^3/ha, respectively) (Figure 1).

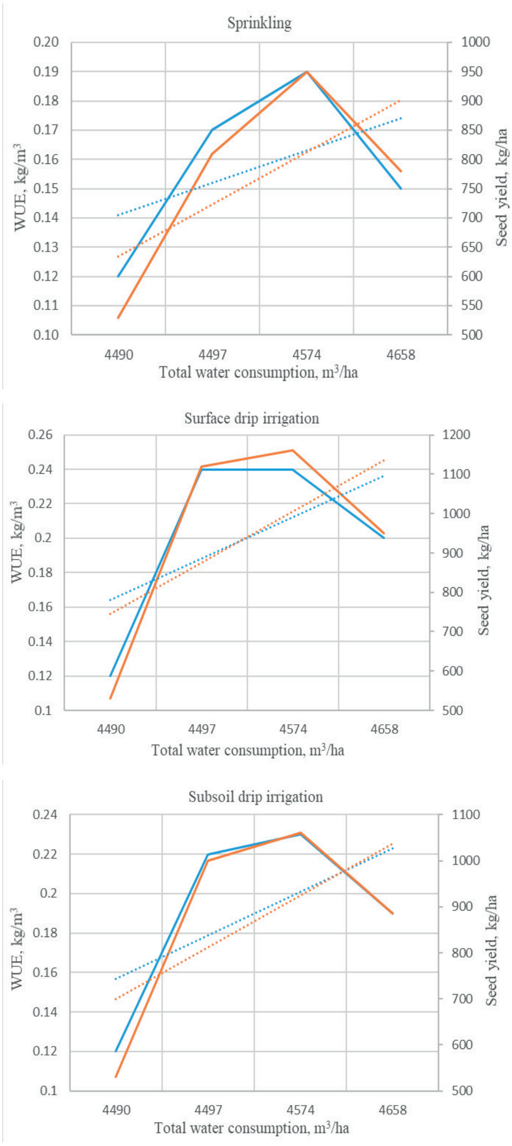

Figure 1. Diagrams of dependencies of total water consumption - water use efficiency and total water consumption - seed yield under different irrigation methods

If we analyze the trend lines and assume that their intersection is optimal, then under irrigation, the optimal total water consumption is 4550 m^3/ha with a yield of 830 kg/ha and a water use efficiency (WUE) of 0.165 kg/m^3. For surface and subsoil drip irrigation - 4500 and 4600 m^3/ha, with yields of 950 and 980 kg/ha and water use efficiency (WUE) of 0.20 and 0.21 kg/m^3, respectively.

CONCLUSIONS

The lowest water consumption of 4497 m3/ha of sesame plants was under subsoil drip irrigation at a soil moisture level of 70-75% HB. Instead, the highest yield of 1160 kg/ha and the highest moisture use efficiency of 0.24 kg/m^3 was obtained with surface drip irrigation at a moisture level of 75-80% HB.

REFERENCES

Abadi (2018). Sesame production, challenges and opportunities in Ethiopia. *Vegetos: An International Journal of Plant Research & Biotechnology*, 31(1), 51-56. https://doi.org/10.5958/2229-4473.2018.00007.1

Abate, M. (2015). Genotype X Environment analysis for seed yield and its components in Sesame (*Sesamum indicum* L.) evaluated across diverse agroecologies of the Awash Valleys in Ethiopia. *J. Adv. Studies Agric. Biol.*, 2(4), 1–14. https://doi.org/10.4334/JABE/2015/2606

Ahmed, E.N.M. & Mahmoud, F.A. (2010). Effect of irrigation on consumptive use, water use efficiency and crop coefficient of sesame (*Sesamum indicum* L.). *Journal of Agricultural Extension and Rural Development*, 2(4), 59–63.

Allen, R.G., Pereira, L.S., Raes, D. & Smith, M. (2006). Evapotranspiración del cultivo: Guias para la determinación de los requerimentos de agua em los cultivos. *Rome: FAO*, 298 p. (Estudio FAO. Riego y Drenaje, 56).

Alpatiev, S.M. (1981). Irrigation regimes for drip and drip-injection irrigation. *Hydrotechnics and Melioration*, 2, 40–44.

Anastasi, U., Sortino, O., Tuttobene, R., Gresta, F., Giuffrè, A.M. & Santonoceto, C. (2017). Agronomic performance and grain quality of Sesame (*Sesamum indicum* L.) landraces and improved varieties grown in a Mediterranean environment. *Genetic Resources and Crop Evolution*, 64, 127–137. https://doi.org/127-137. 10.1007/s10722-015-0338-z

Ashri, A. (2007). Sesame (*Sesamum indicum* L.). In R.J. Singh (Ed), Oilseed Crops. In Genetics Resources, Chromosome Engineering, and Crop Improvement (pp. 231-289). CRC Press, Boca Raton, FL, USA.

Bahrami, H., Razmjoo, J. & Jafari, A.O. (2012). Effect of drought stress on germination and seedling growth of Sesame cultivars (*Sesamum indicum* L.). *International Journal of AgriScience*, 2(5), 423–428.

Cheng, F.C., Jinn, T.R., Hou, R.C.W. & Tzen, J.T.C. (2006). Neuroprotective effects of sesamin and sesamolin on gerbil brain in cerebral ischemia. *Int. J. Biomed. Sci.*, 2, 284–288.

Cooney, R.V., Custer, L.J., Okinaka, L. & Franke, A.A. (2001). Effects of dietary sesame seeds on plasma tocopherol levels. *Nutr. Cancer*, 39, 66–71.

Dagmawi, T.W., Kassahun, T. & Endashaw, B. (2015). Genetic diversity of sesame germplasm collection

(*Sesamum indicum* L.): implication for conservation, improvement and use. *International Journal of Biotechnology and Molecular Biology Research.* 6(2), 7–18.

Deepthi, P., Shukla, C.S., Verma, K.P. & Siva Sankar Reddy, E. (2014). Yeild Assessment and Influence of Temeperature and Relative Humidity on Charcoal Rot Development in Sesame (*Sesamum indicum* L.). *The Bioscan*, 9, 193–195.

De Lima, G.S., De Lacerda, C.N., Dos Anjos Soares, L.A., Gheyi, H.R. & Araujo, R.H.C.R. (2020). Production characteristics of sesame genotypes under different strategies of saline water application. *Rev. Caatinga, Mossoró*, 33(2), 490–499. https://doi.org/10.1590/1983-21252020v33n221rc.

Dias, A.S., De Lima, G.S., Gheyi, H.R., Nobre, R.G. & Dos Santos, J.B. (2017). Emergence, growth and production of sesame under salt stress and proportions of nitrate and ammonium. *Revista Caatinga*, 30(2), 458–467. http://dx.doi.org/10.1590/1983-21252017v30n221rc

Ekom, D.C.T., Guidjinga, K.N.A., Memena, O., & Nome, A.T. (2019). Performance of sesame seeds produced from plants subjected to water stress for early selection of tolerant genotypes. *International Journal of Plant & Soil Science*, 28(1), 1–10. https://doi.org/10.9734/ijpss/2019/v28i130096

Eskandari, H., Hamid, A. & Alizadeh-Amraie, A. (2015). Development and maturation of Sesame (*Sesamum indicum*) seeds under different water regimes. *Seed Science and Technology*, 43(2), 269–272. https://doi.org/10.15258/sst.2015.43.2.03

Girmay, A.B. (2018). Sesame production, challenges and opportunities in Ethiopia, *Vegetos - An International Journal of Plant Research*, 31(1), 51. https://doi.org/10.13140/RG.2.1.1296.6481

Hailu, E.K., Urga, Y.D., Sori, N.A., Borona, F.R. & Tufa, K.N. (2018). Sesame Yield Response to Deficit Irrigation and Water Application Techniques in Irrigated Agriculture, Ethiopia. *International Journal of Agronomy*, 2018, 6. https://doi.org/10.1155/2018/5084056

Hsu, D.Z., Su, S.B., Chien, S.P., Chiang, P.J., Li, Y.H., Lo, Y.J. & Liu M.Y. (2005). Effect of sesame oil on oxidativestress-associated renal injury in endotoxemic rats: involvement of nitric oxide and proinflammatory cytokines. *Shock*, 24, 276–280.

[a]Konovalova, V., Konovalov, V., Tyshchenko, A., Tyshchenko, O., Roi, S., Reznychenko, N., Sharii, V., Fundirat, K. (2023). The efficiency of the application of preparations based on adhesive and surfactant substances and desiccants in growing sesame seeds. *Scientific Papers. Series A. Agronomy, LXVI(2),* 286–293.

[b]Konovalova, V., Roi, S., Tyshchenko, A., Sharii, V., Tyshchenko, O., Konovalov, V., Reznychenko, N., Fundirat, K. (2023). Efficiency and economic evaluation of different methods of irrigation in growing corn (*Zea mays* L.). *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 23(4),* 461–466.

Lavrynenko, Y., Tyshchenko, A., Bazalii, H., Konovalova, V., Zhupyna, A., Tyshchenko, O., Piliarska, O., Marchenko, T., Fundirat, K. (2023). Ecological plasticity and stability of winter wheat varieties in the conditions of Southern Ukraine. *Scientific Papers. Series A. Agronomy, LXVI(2),* 294–301.

Meena, H.M. & Rao, A.S. (2015). Determination of actual evapotranspiration and crop coefficient of sesame (*Sesamum indicum* L. CV. RT-127) from lysimetric studies. *An international quarterly journal of environmental sciences*, 9(3&4), 765–769.

Mekonnen, S.A. & Sintayehu, A. (2020). Performance Evaluation of Sesame under Regulated Deficit Irrigation Application in the Low Land of Western Gondar, Ethiopia. *International Journal of Agronomy*, 2020, 9. https://doi.org/10.1155/2020/3760349

Nadeem, A., Kashani, S., Ahmed, N., Buriro, M., Saeed, Z., Mohammad, F. & Ahmed, S. (2015). Growth and yield of sesame (*Sesamum indicum* L.) under the influence of planting geometry and irrigation regimes. *American Journal of Plant Sciences*, 6(7), 980-986. http://dx.doi.org/10.4236/ajps.2015.67104

Nakano, D., Kurumazuka, D., Nagai, Y., Nishiyama, A., Kiso, Y. & Matsumura Y. (2008). Dietary sesamin suppresses aortic NADPH oxidase in DOCA salt hypertensive rats. *Clin. Exp. Pharmacol. P.*, 35, 324–326.

Namiki, M. (2007). Nutraceutical functions of sesame: a review. *Crit Rev Food Sci.*, 47, 651–673.

Pabuayon, I.L.B., Singh, S., Lewis, K.L. & Ritchie G.L. (2019). Water extraction and productivity of cotton, sorghum, and sesame under deficit irrigation, *Crop Science*, 59(4), 1692–1700.

Sharaby, N. & Butovchenko, A. (2019). Cultivation technology of sesame seeds and its production in the world and in Egypt. *IOP Conf. Ser.: Earth Environ. Sci.*, 403.

Tewelde, A.G. (2019). Evaluating the Economic Water Productivity underfull and deficit irrigation; the case of sesamecrop (*Sesumum indicum* L.) in woreda Kafta-Humera, Tigrai-Ethiopia. *Water Science*, 33(1), 65–73.

[a]Tyshchenko, O., Tyshchenko, A., Piliarska, O., Biliaeva, I., Kuts, H., Lykhovyd, P. & Halchenko, N. (2020). Seed productivity of alfalfa varieties depending on the conditions of humidification and growth regulators in the Southern Steppe of Ukraine. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 20(4), 551–562.

[b]Tyshchenko, O., Tyshchenko, A., Piliarska, O., Kuts, H. & Lykhovyd, P. (2020). Evaluation of drought tolerance in alfalfa *(Medicago sativa)* genotypes in the conditions of osmotic stress. *AgroLife Scientific Journal*, 9(2), 353–358.

Ucan, K., Killi, F., Gencoglan, C. & Merdun, H. (2007). Effect of irrigation frequency and amount on water use efficiency and yield of sesame (*Sesamum indicum* L.) under field conditions. *Field Crops Res*, 101(3), 249–258.

Visavadiya, N.P. & Narasimhacharya, A.V.R.L. (2008). Sesame as a hypocholesteraemic and antioxidant

dietary component. *Food Chem. Toxicol.*, 46, 1889-1895.
[a]Vozhehova, R., Tyshchenko, A., Tyshchenko, O., Dymov, O., Piliarska, O. & Lykhovyd, P. (2021). Evaluation of breeding indices for drought tolerance in alfalfa (*Medicago*) genotypes. *Scientific Papers. Series A. Agronomy*, LXIV (2), 435–444.
[b]Vozhehova, R., Tyshchenko, A., Tyshchenko, O., Piliarska, O., Konovalova, V., Sharii, V. & Fundirat, K. (2022). Economic feasibility of application of bacterial and fungal drugs on seed-used alfalfa. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 22(4), 827–834.
Wei, X., Liu, K., Zhang, Y., Feng, Q., Wang, L., Zhao, Y., Li, D., Zhao, Q., Zhu, X., Zhu, X., Li, W., Fan, D., Gao, Y., Lu, Y., Zhang, X., Tang, X., Zhou, C., Zhu, C., Liu, L., Zhong, R., Tian, Q., Wen, Z/, Weng, Q., Han, B., Huang, X. & Zhang, X. (2015). Genetic discovery for oil production and quality in Sesame. *Nature Communications*, 6.
Yokota, T., Matsuzaki, Y., Koyama, M., Hitomi, T., Kawanaka, M., Enoki-Konishi, M., Okuyama, Y., Takayasu, J., Nishino, H., Nishikawa, A., Osawa, T. & Sakai T. (2007). Sesamin, a lignan of sesame, down-regulates cyclin D1 protein expression in human tumor cells. *Cancer Sci.*, 98, 1447-1453.
Zhang, H., Miao, H., Wang, L., Qu, L., Liu, H., Wang, Q., & Yue, M. (2013). Genome sequencing of the important oilseed crop *Sesamum indicum* L. *Genome Biology*, 14(1), 401. doi:10.1186/gb-2013-14-1-401