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STATE AND PROSPECTS OF SUNFLOWER PRODUCTION IN UKRAINE

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ABSTRACT

Sunflower (*Helianthus annuus* L.) is among the three most significant oilseed plants in the world (along with, soybean and rapeseed) and one of the two most produced oil crops in the European Union, together with rapeseed. Over the past decade, Ukraine has maintained its position as leading producer and exporter of sunflower seeds and ranks first for sunflower oil consumption globally. A recent United States Department of Agriculture report in 2017 suggest that, Ukraine presently (2015−2016) ranks first in sunflower production globally with a 29.3 % share of total world sunflower output of 40.57 million metric tons. Respectively, Russia and the European Union are currently ranked second and third, with a share of 22.6 % and 18.9 %, followed by Argentina and China that produced 6.7 % each. The main goal in sunflower breeding is to create hybrids with high genetic potential for seed yield above 5 t/ha, but environmental factors seems to limit current sunflower yields to the production range of 1.5–3.0 t/ha. In this study, however, we report new sunflower varieties and hybrids in Ukraine that yield even slightly above 3 t/ha. Thus, a unique sunflower production technology for the forest-steppe of Ukraine for instance now provides sunflower seed yields of 2.9-3.5 t/ha. This became possible after the introduction of new high-yielding varieties and hybrids, and the improvement of sunflower cultivation technologies for specific natural and climatic zones. Hence, further increases in global sunflower seeds output mainly from Ukraine are expected without expansions in limited agricultural lands.

Keywords: *sunflower,varieties and hybrids, yield, environmental factors, Ukraine.*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is among the three most significant oilseed plants in the world (along with, soybean and rapeseed) and one of the two most produced oil crops in the European Union, together with rapeseed (United States Department of Agriculture - USDA, 2017). A recent USDA report in 2017 suggest that, Ukraine presently (2015−2016) ranks first in sunflower production globally with a 29.3 % share of total world sunflower output of 40.57 million metric tons

(USDA, 2017). Respectively, Russia and the European Union are currently ranked second and third, with a share of 22.6 % and 18.9 %, followed by Argentina and China that produced 6.7 % each.

It is indicated that, due to the genetic variability of cultivated sunflowers, it is possible to develop hybrids with a genetic potential for seed yields of over 6 t/ha and seed oil content above 55% (Škorić et al., 2007; Škorić, 2012). Even more recently, Jocić et al., (2015) similarly stated that, the main goal in sunflower breeding is to create hybrids with high genetic potential for seed yield above 5 t/ha and oil content in seed of over 50%. In spite of this well documented potential, environmental factors seems to limit current sunflower yields to the production range of 1.5–3.0 t/ha (Kaya, 2015). Just recently, Kaya (2015) advised that Breeders should pay meticulous attention to eliminating or minimizing extreme environmental factors to ensure that a minimum of 4.0 t/ha sunflower yields are reached.

The present study therefore investigates the range of sunflower seed yield and oil content of improved hybrids under the climatic condition of the Forest steppe of Ukraine. We also ascertained the dynamics of sunflower seed production (output) along with two major oilseeds (Soybean and rapeseed) in Ukraine for the past 16 years (2000−2016).

MATERIALS AND METHODS

The object of the research is sunflower (*Helianthus annuus* L.), namely the cultivated area, yield and elements of cultivation technology in the forest-steppe of Ukraine for the period from 2000 to 2016. Secondary data and reports were obtained from the State Statistics Service of Ukraine.

The experimental part of the work was conducted at the training and practical center of Sumy National Agrarian University (Ukraine) for two years (2015 and 2016). Experiments were laid on black soil, characteristic for coarse-medium loam. Five hybrids were sown at 3 plant densities (50, 60 and 70 thousand plants/ha) with 6 rows in each plot and 70 cm between rows. Harvesting was done manually at maturity by harvesting two inner rows in each plot.

Hydrothermal coefficient (HTC) (G. T. Selyaninov) were determined by the formula: $HTC=\sum K / \sum T \times 10$, where ∑K is the amount of precipitation, mm, for a period with an average daily air temperature above 10 °C; ∑T is the sum of the temperatures, °C, for the period with the average daily air temperature above 10 °C. The oil content of the seeds was determined using the device Spinlock Magnetic Resonance Solutions. Data were subjected to ANOVA at 5% level of probability with the statistical software STATISTICA (version 8).

RESULTS AND DISCUSSIONS

The significant potential of sunflower seeds production in Ukraine is evidenced by the positive dynamics of total harvest of sunflower seeds over the past sixteen years (Figure 1). The main component for increasing production is the increase in sunflower seed yield. Thus, the maximum gross indicator of 13626.9 thousand tons

was obtained in 2016. The main areas of sunflower production currently are Kirovogradskaya (11.5%), Kharkivska (11.4%), Dnipropetrovsk (9.3%), Zaporizhzhia (7.6%), Donetsk (7.3%), Mykolayivska 7.2%). It should be noted that, there has been an increase in the share of sunflower seed production in the Central and Northern regions of Ukraine, in particular in Poltava (7.0%), Vinnytsa (5.3%), Cherkasy (4.9%), Sumy (4.2%) and Chernihiv (3.0%) (http://www.ukrstat.gov.ua/).

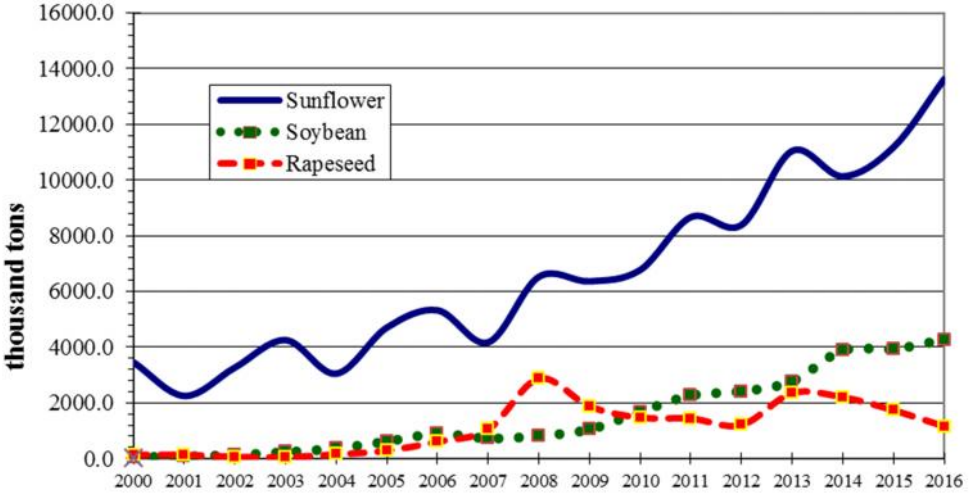

Figure1. Dynamics of seed production of major oilseeds in Ukraine from 2000-2016

(Adapted from State Statistics Service of Ukraine, http://www.ukrstat.gov.ua/)

The second place among oilseeds produced in Ukraine is soybean. According to the State Statistics Service of Ukraine, in 2016, the soybean area cultivated was 1.87 million hectares compared to 60.6 thousand in 2000. During this period, the productivity of the crop increased from 1.1 to 2.4 t/ha. In recent years, there has been a tendency to reduce production of rapeseed, due to the decline in world oil prices, as well as cheap raw materials for energy production. A similar situation is observed in Ukraine, its area is limited, and the production of seeds and oils from it is not always effective from an economic point of view. The main reason for this condition is the possibility of death due to unfavorable conditions and low yield of the seeds of this crop. Sunflower is a typical crop of the steppe and forest-steppe zone of Ukraine. The success of its cultivation is largely determined by the changing environmental conditions, that is, weather and climate. Observations by the metrological network of Ukraine testify to the fact that regional climate change, especially temperature rise, has already affected a number of meteorological characteristics. The average annual air temperature has increased, the terms of formation and duration of snow cover have changed, the heat supply of the growing season gradually increased, and the number and intensity of adverse

meteorological phenomena (drought, heavy rain, etc.) has increased (Melnik et al., 2015). For example, in the Forest-steppe of Ukraine we considered the main meteorological parameters for the period from 2000 to 2016 (Table 1).

Table 1.Total temperature, total precipitation (rainfall) and hydrothermal coefficients (HTC) in the Forest-steppe of Ukraine (April-August) from 2000−2016

Year	Total temperature, ° C	Totalprecipitation, mm	HTC	Moisture for the year
2000	2528.2	269.2	1.06	normal
2001	2567.5	319.3	1.24	normal
2002	2653.1	292.6	1.10	normal
2003	2419.7	258.9	1.07	normal
2004	2311.2	351.9	1.52	wet
2005	2740.7	202.8	0.74	dry
2006	2511.5	365.7	1.46	wet
2007	2608.9	198.7	0.76	dry
2008	2626.1	304.5	1.16	normal
2009	2559.6	319.2	1.25	normal
2010	3132.2	171.4	0.55	dry
2011	2839.4	253.5	0.89	dry
2012	3090.7	218.8	0.71	dry
2013	2956.4	213.1	0.72	dry
2014	2899.8	284.1	0.98	dry
2015	2777.6	306.4	1.10	normal
2016	2865.6	461.7	1.59	wet
Average 2000−2016	2710.8	281.9	1.05	normal
Average perennial	2425.0	294.0	1.21	normal
Deviation of the parameters	285.8	-12.1		

Thus, according to the results of the analysis of meteorological conditions for 16 years, it has been established that for the period of the growing (farming) season (April-August), there was an average of 281.9 mm of rainfall, with fluctuations from 171.4 to 461.7 mm. In this region, the average temperature during this period amounted to 2710.8 ° C with fluctuations ranging from 2311.0 °C to 3090.7 °C. Increase in the heat supply of the growing season was noted at 285.8 ° C and decrease in the amount of precipitation by 12.1 mm. Based on HTC which for the past 16 years has decreased from 1.21 to 1.05, it was established that the conditions of this region correspond to the conditions of the Steppe zone of Ukraine. The temperature and moisture differed for the investigated years. From the data given (Table 1), dry conditions (HTC to 1.0) were the growing periods 2005, 2007, 2010, 2011, 2012, 2013, 2014, normal moisture (HTC 1.0-1.3) - 2000, 2001, 2002, 2003 , 2008, 2009, 2015 and wet conditions (HTC above 1.3) were only in 2004, 2006 and 2016. The influence of moisture conditions on yield is clearly shown (Figure 2).

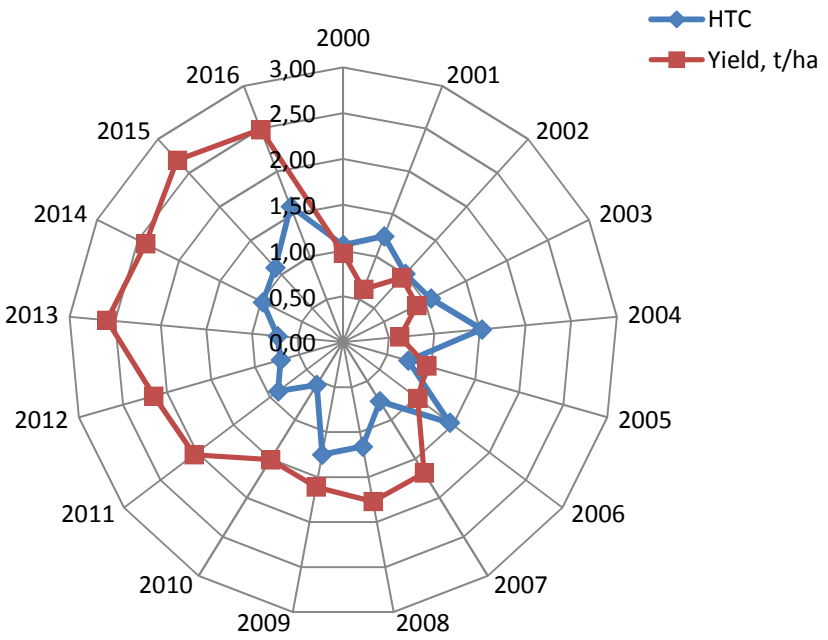

Figure 2. Dynamics ofaverage yield of sunflower and HTC under the conditions of the Forest-steppe of Ukraine (for the period of 2000-2016)

It should be noted that, there was positive dynamics in the increase in average yields of sunflower seeds in the forest-steppe of Ukraine in recent years from 0.62 t/ha to 2.69 t/ha. The highest average yield of seeds was obtained in dry and normal moisture years, while the lowest were in years with excessive moisture. The revealed facts prove that under the conditions of low temperatures and excessive moisture, the growing season of plants is prolonged, and harvesting falls in October, which causes massive damage to plants by diseases. According to results of research conducted in 2010-2015 at the Department of Crop Production in Sumy National Agrarian University in Ukraine, a regional technology for sunflower cultivation, which involves the selection of adapted hybrids and optimization elements was developed. According to the Ukrainian State Register for Plant Varieties (SRPV), in 2017, the agricultural producer presently have 740 varieties and hybrids of sunflower of which 664 are linoleic, 51 - high oleic, 22 - confectionery and palmitic − 3. An important segment of the market in Ukraine is occupied by high-performance adapted hybrids of domestic breeding: the Institute of Plant Cultivation V. I. Yuryev NAANU (52), Institute of Oilseeds of NAANU (23), Selection-Genetic Institute of NAANU (11), VNIS Ltd. (11), Ukrainian Seed Ltd. (11) and a number of other institutions.

The share of hybrids of sunflower from foreign selection is growing, in particular, the Institute of Agriculture and Horticulture, Novi Sad, Serbia (70), Euralis Semans, France (66), Syngenta, Switzerland (49), Maisadur Semans, France (41),

Kossad Semans ES , France (33), Limagrain Europe, France (28), Pioneer, Austria (26), ASPIRIA SIDS ESA, Luxembourg (19), Dow AgroSciences, Austria (15) (SRPV, 2017). The ecological testing of the modern sunflower seeds by us for this natural-climatic zone recommends these hybrids: Gaychur, Zlatson(Institute of Plant Science named after V.I. Guryev, Ukraine); Consul, Coral, Rehion (Institute of Oilseeds, Ukraine); PR63A86, PR63A90, PR64A71, PR64H32 (Pioneer, Austria), LG55.50 (Limagrain Europe, France); Condi, Tutti, Tehnika brio (Syngenta, Switzerland); Artic, Balistic, (Euralis, France). When these hybrids were harvested, more than 3.5 t/ha of seeds and 1.5 t/ha of oil were obtained.

It is known that sunflower is quite sensitive to the application of organic and mineral fertilizers. For the formation of 100 kg of seeds, it requires nitrogen – 4−6 kg, phosphorus – 2−5 kg, potassium – 10−12 kg, magnesium 1.6−3.0 kg, sulphur 2.6−6 kg, calcium 6−10 kg. Sunflower requires much microelement, particularly boron 9−16 g, manganese 10−17 g, zinc 14−23 g (Hugger, 1992). Under the influence of fertilizers, the assimilation surface increases and photosynthesis increases. It is established that the highest yield was collected using a complete mineral fertilizer in a dose of $N_{45-60}P_{60-90}K_{45-60}$. The following schemes of fertilization are offered: application of organic fertilizers at a dose of 20−40 t/ha provides an increase in yields of 0.34−0.51 t/ha; application of complete mineral fertilizer $N_{30}P_{30}K_{30}$ under cultivation contributes to the increase in yield by 0.52 t/ha; application in a 4-leaf phase in a dose of $N_{10}P_{10}K_{10}$ increases the yield by 0.34 t/ha. To realize the biological potential of modern high-yield sunflower hybrids, it is important to provide plants with trace elements for a sufficient level of nutrition with nitrogen, phosphorus and potassium. Given the proven role of most of them in the formation of the cryoprotective ability of plant organism and complex tolerance regarding the abiotic and biotic adverse environmental factors, it is relevant to study their effectiveness for the modern changes in climatic conditions. A particularly important issue nowadays is the study of mechanisms for reducing the negative impact ofcrop productivity under stressful conditions, which are typical for the last 2016 and 2017. These last two years in the Forest-steppe of Ukraine are characterized by sharp fluctuations of the temperature regime from 5−10 °C to 29−32 °C, excessive rainfall (10−15 mm per day) and dry periods (no rainfall for the month). Our preliminary research confirmed the effect of foliar application of fertilizers and plant growth regulators on productivity of sunflower plants, but the effectiveness of this agro-activity depends on the current weather conditions and requires further investigation. Spraying of crops before flowering (Sol Bor + Basfoliar 6-12-6; Wuxal Bio Aminoplant + Wuxal Boron; Spectrum Askorist + Spectrum B + Mo) resulted in a yield increase of 7.5−9.3%. These preparations contain: N, P_2O_5, K_2O, MgO, Mn, Cu, Fe, B, Zn, Mo, K, Amino acids, Seaweed extract of *Ascophyllum nodosum.* They were applied based on recommended concentrations (2.0−3.0 l/ha) by manufacturers. One of the most important elements of ecologically safe technologies is the use of microbiological preparations (agents) that improve plant nutrition, and increase resistance to harmful organisms. Such preparations are based on nitrogen-fixing, phosphorus-

forming and antagonist bacteria. The positive effect of bacterial preparations on the development of agricultural plants is manifested in the secured higher yields of seeds. Our earlier research proved the feasibility of application of *Paenibacillus polymyxa KB*, which provides an increase of 11.6-16.1% and *Achromobacter album 1122* by 8.8-12.7% yield of sunflower seeds in the cultivars and hybrids (Melnyk, 2011). Plant density determines the level of provision of plants with moisture and nutrients, hence only properly formed plant density will ensure high sunflower yields. We have established that for Rehion and Tutti hybrids, optimal conditions are created for plant stand density at 60 thousand plants/ha. Harvested seeds in these hybrids generated 3.71 and 3.84 t/ha respectively. The maximum yields in the hybrids Zlatson (3.78 t/ha), ES Artic (3.74 t/ha) and PR64H32 (3.51 t/ha) were obtained for plant densities 70 thousand plants/ha (Figure 3).

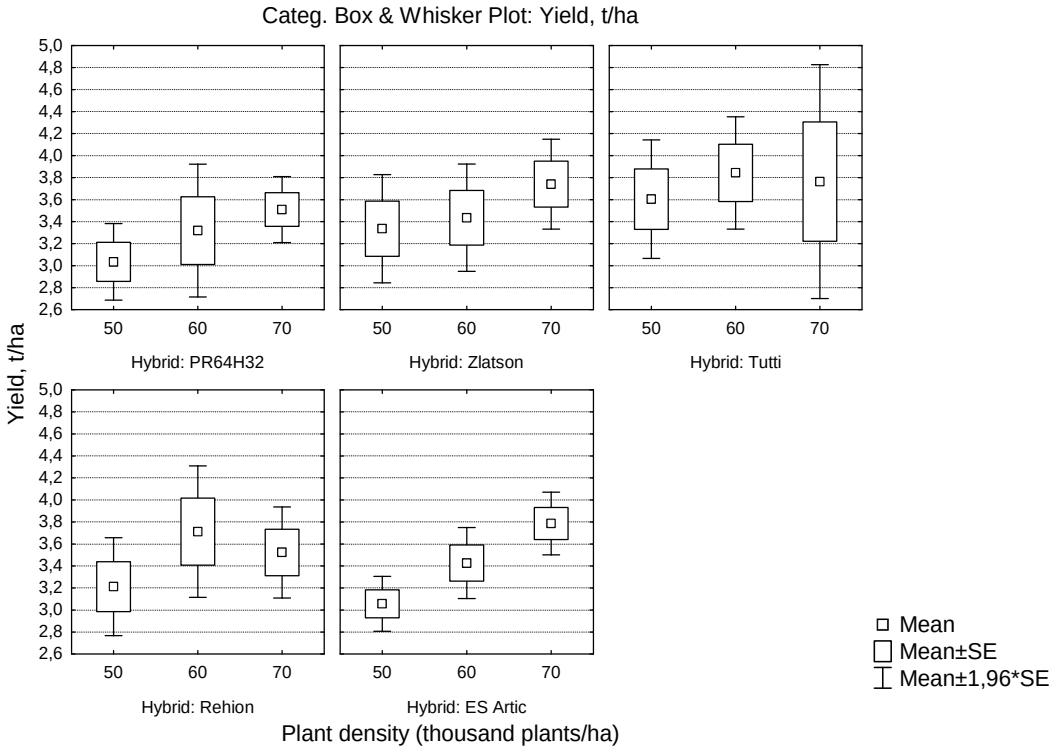

Figure 3. Yield of modern sunflower hybrids depending on the plant density (Average for 2015-2016)

On average, the studied hybrids ensured the formation of yields at the following level: Tutti (3.73 t/ha); Zlatson (3.59 t/ha); ES Artic (3.56 t/ha); Rehion (3.49 t/ha) and PR64H32 (3.37 t/ha). Under the two years (2015-2016) conditions,the oil contents for these sunflower seeds were as follows: Tutti – 47.2%; Zlatson - 46.3%; ES Artic - 47.3%; Rehion – 47.4% and PR64H32 – 48.6%.

CONCLUSION

According to the results of the analysis, trends in the meteorological parameters caused the expansion of the range of area under sunflower cultivation in Ukraine, which contributed to the increase in total national production of oilseeds. Having all the opportunities (natural, climatic, logistical and human), Ukraine will increase its presence in the world market of oilseeds. Over the past 16 years, Ukraine has increased its annual production of sunflower seeds from 3.4 million tons to 13.6 million tons. It should be noted that the increase in output over this period is more than 4 times. The main prerequisites for sustainable high sunflower harvest in Ukraine are the use of modern high-yielding hybrids and the development of regional cultivation technologies for specific climatic zones which are currently being employed. Hence, further increases in global sunflower seeds output mainly from Ukraine are expected without expansions in limited agricultural lands.

REFERENCES

Hugger H. (1992). Nährstoffansprüche und Düngung der Sonnenblume (Nutrient requirements and fertilization of sunflower). Raps. 10 (1) 39−42.

Jocić, S., Miladinović, D., & Kaya, Y. (2015). Breeding and genetics of sunflower. In F. E. Martínez, N. T. Dunford, & J. J. Salas (Eds.), Sunflower: Chemistry, production, processing, and utilization (pp. 1-26). Urbana, IL: AOCS Press.

Kaya, Y. (2015). Sunflower. In S. K. Gupta (Ed.), Breeding oilseed crops for sustainable production: Opportunities and constraints (pp. 55-88). San Diego, CA: Academic Press.

Melnik, A. V., Zherdetska, S. V., Ali, S., Romanko, Y. O., Makarchuk, A. V., Akuaku, J. (2015). State and prospects for growing oil crops in Ukraine under the conditions of climate change. Science and World, 1(10), 113−116.

Melnyk, A.V. (2011). The perspectives of the bacterial preparations usage on the sunflower sown area according to the conditions of the Northeastern part of Ukraine, Bulletin of Sumy National Agrarian University, 4 (21), 66–70.

SRPV (2017). State Register of Plant Varieties Suitable for dissemination in Ukraine in 2017. http://sops.gov.ua/reiestr-sortiv-roslyn-ukrainy (Accessed on July 8, 2017).

State Statistics Service of Ukraine. Crop Production (1990−2016). http://www.ukrstat.gov.ua/ (Accessed on July 5, 2017).

USDA (United States Department of Agriculture). (2017, March 9). Production, supply, and distribution (PSD) reports-Oilseeds. https://apps.fas.usda.gov/psdonline/app/index.html#/app/downloads?tabName=default (Accessed March 28, 2017)

Škorić, D. (2012).The genetics of sunflower.In D. Škorić& Z. Sakač (Eds.), Sunflower genetics and breeding (pp. 1−163). Novi Sad, Serbia: Serbian Academy of Sciences and Arts.

Škorić, D., Jocić, S., Lecic, N., & Sakac, Z. (2007). Development of sunflower hybrids with different oil quality. *Helia*, *30*(47), 205-212. doi: 10.2298/hel0747205s