

Study on performance of sunflower hybrids (*Helianthus annuus*) under the conditions of the Southern steppe of Ukraine

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Receipt: 22.01.2026 Revised: 10.03.2026 Acceptance: 12.03.2026

DOI: <https://doi.org/10.53552/ijmfmap.12.1.2026.186-191>

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ABSTRACT

The research sought to identify the optimal sunflower hybrids for cultivation in the Southern Steppe of Ukraine. The study focused on climate stress adaptation, yield, oil content and disease resistance to select the best sunflower hybrids for agriculture in the Southern Steppe of Ukraine. The study found that hybrids with a shorter vegetation cycle, such as Lorys SLP (105-107 days), Averno SU (109-115 days), and Insan 222 KLP (109-115 days), were highly adaptable to autumn droughts, allowing them to finish the vegetation period before critical drought conditions, ensuring stable yields even with limited water supply. The hybrid Aluris KLP (105-107 days) had the best yield (4.6-5 t/ha) and oil content (52-54%), although its productivity depended on appropriate moisture during seed filling and ripening. The Aluris KLP hybrid had the highest oil content (52-54%) and oil output (2.29-2.59 t/ha), which increased the crop's economic efficiency. All hybrids are highly resistant to broomrape (races A-G), which helps manage critical diseases under regional settings. The Insan 222 KLP hybrid is promising for growing under strong disease pressure because to its great phomopsis resistance.

Keywords: Agrobiological characteristics, disease resistance, hybrids, oil content, oil output, stress adaptability, vegetation period, yield,

INTRODUCTION

Sunflower oil, extracted from the seeds is acknowledged for its various therapeutic attributes. It is abundant in polyunsaturated fatty acids, particularly linoleic acid, which may aid in lowering cholesterol levels and diminishing the risk of cardiovascular illnesses. The oil additionally comprises antioxidants, including vitamin E, which possesses anti-inflammatory and anti-aging properties. Moreover, sunflower oil possesses skin-repairing attributes and is utilised in cosmetics and dermatology for the treatment of burns, wounds, and skin irritations (Fecker *et al.*, 2022). The elevated

vitamin E concentration contributes to skin health by mitigating oxidative stress and facilitating cell regeneration. Additionally, sunflower oil has been historically utilised in traditional medicine for its capacity to mitigate digestive disorders and enhance liver health. Its anti-inflammatory and antioxidant properties render it advantageous in the management of ailments such as arthritis and other inflammatory disorders. These attributes render sunflower oil a multifaceted culinary ingredient as well as a significant element in medicinal and cosmetic uses.

Studying sunflower growing methods in the Southern Steppe of Ukraine is

important to maintain consistent and effective oil crop production in drought-prone and water-scarce locations. Due to climate change, especially increasingly frequent and extreme droughts, sunflower agriculture technologies must be optimised, including hybrid selection and agrotechnical improvements. Rising temperatures, changing rainfall patterns, and more dry periods make traditional sunflower production methods less successful in Ukraine's Southern Steppe (Kozechko and Ivanchenko, 2025; Hussain *et al.*, 2022). This requires innovative cultivar selection, agrotechnical, and water resource management methods. To solve this problem, hybrids that yield well and survive drought, high temperature, and unreliable water supply must be developed and introduced (Aliyeva *et al.*, 2025). Thus, study in this subject benefits farmers and the nation's economy.

Limited research has examined the synergistic impacts of local agro-climatic variables and agrotechnical techniques on the performance of sunflower hybrids in Ukraine's Southern Steppe. Furthermore, research on the resilience of novel hybrids to regional drought and temperature conditions is sparse, as are practical recommendations for farmers facing restricted water supplies (Balakrishna *et al.*, 2024; Bolokhovskiy *et al.*, 2024). Rectifying these deficiencies is essential for enhancing sunflower yield amid evolving climatic conditions. The study aimed to evaluate the phenological and morphological characteristics of sunflower hybrids grown in the Southern Steppe and their adaptability to regional stress factors, on yield and oil content under limited water supply, and provide recommendations on hybrids suitable for the region.

MATERIALS AND METHODS

The field experiment was conducted during the 2022–2024 growing seasons under the conditions of the Southern Steppe of Ukraine. The experimental plots were located at Farm Enterprise “Olena”, Ivanivka Village, Ukraine, in cooperation with Mykolaiv National Agrarian University, 9 Georgiy Gongadze Street, Mykolaiv, 54020, Ukraine. The experiment started with sunflower

sowing in spring 2022 and was completed after harvesting and laboratory analysis of seed samples in 2024 [from 20 April 2022 to 25 September 2024].

Five sunflower hybrids (*Helianthus annuus* L.) were used as the experimental material: Averno SU, Insho 200 KLP, Insho 222 KLP, Lorys SLP, and Aluris KLP. Certified seeds of the hybrids were obtained from official commercial seed sources before sowing. The hybrids Averno SU, Insho 200 KLP, Insho 222 KLP, Lorys SLP, and Aluris KLP are listed in the BASF Agricultural Solutions seed portfolio for Ukraine, and their declared characteristics include resistance to sunflower broomrape races A–G and tolerance or resistance to major sunflower diseases.

The experiment was arranged as a field comparative trial using a randomized complete block design with five treatments, represented by the five sunflower hybrids, and three replications. Each hybrid was grown in each replication under the same soil, climatic, and agronomic conditions. Standard sunflower cultivation practices recommended for the Southern Steppe of Ukraine were followed throughout the experiment. The same sowing method, plant density, inter-row spacing, fertilisation background, weed control, and harvesting procedure were applied to all treatments in order to ensure comparability among hybrids.

Phenological, morphological, yield-related, seed-quality, and stress-resistance observations were recorded during the 2022–2024 growing seasons. The maturity group and duration of the vegetation period were determined by recording the number of days from seedling emergence to physiological maturity. Plant height was measured at physiological maturity from the soil surface to the top of the plant. Head diameter was measured across the central part of the sunflower head at maturity. These observations were used to obtain the data presented in Table 1.

Seed yield was determined after harvesting each experimental plot and recalculated into tonnes per hectare. Seed samples from each replication were taken after harvest for laboratory analysis. Oil content, husk content,

and protein content in the kernel were determined using standard seed-quality analytical procedures. Oil yield was calculated on the basis of seed yield and oil content. These measurements formed the basis of the data presented in Table 2.

The tolerance and resistance of the studied hybrids to abiotic and biotic stress factors were assessed during the growing period and after maturity. Drought resistance, heat resistance, and water-use efficiency were evaluated on the basis of field performance under rainfed conditions, visual plant condition, maintenance of growth, and yield stability under high-temperature and moisture-deficit conditions. Resistance to phomopsis (*Phomopsis helianthi*), powdery mildew (*Erysiphe cichoracearum*), grey mould, and sunflower broomrape (*Orobancha cumana*, races A-G) was assessed using field observations of disease symptoms and hybrid resistance characteristics declared in official varietal and seed-source descriptions. These observations were used to classify the hybrids as having high or medium resistance, as presented in Table 3.

The data obtained from the three-year experiment were averaged for 2022-2024. Statistical analysis was performed using analysis of variance to determine the significance of differences among sunflower hybrids. The critical difference value at the 5% significance level was calculated for the main quantitative traits, including vegetation-period characteristics, plant height, head diameter, seed yield, oil content, oil yield, husk content, and protein content in the kernel. Differences among hybrids were considered statistically significant when the calculated differences exceeded the critical difference value at $p \leq 0.05$.

RESULTS AND DISCUSSION

Phenological properties of the sunflower hybrids

The phenological properties of the sunflower hybrids showed considerable variation in the vegetation period. Hybrids exhibited different maturity levels: Insanho 200 KLP and Aluris KLP were late-maturing,

Lorys SLP was medium-early, and Averno SU and Insan 222 KLP were mid-season. This variation affected the duration from emergence to physiological maturity, with Lorys SLP having the shortest vegetative period, while Aluris KLP and Insanho 200 KLP had the longest (Table 1). In the Southern Steppe of Ukraine, which is prone to autumn air and soil dryness, hybrids with shorter vegetative cycles, like Lorys SLP, completed the main development stages and reached technological maturity before critical drought conditions, indicating higher adaptability (Shahini *et al.*, 2023a; 2023b). In contrast, late-maturing hybrids such as Insanho 200 KLP and Aluris KLP require sufficient water during grain filling and seed ripening to achieve maximum productivity. Morphophysiological analysis revealed variations in plant architecture. Plant height ranged from medium to high, and head diameter from medium to extremely large. Lorys SLP exhibited the tallest plants and the largest head diameter, suggesting high productivity, but also a higher risk of lodging under adverse weather. Insanho 200 KLP had a more compact structure, with an optimal plant height-generative organ ratio, enhancing lodging resistance (Table 1). Morphological features varied among hybrids: Averno SU had the smallest plant height (145-160 cm) and head diameter (18-22 cm), Lorys SLP showed the most developed vegetative and generative structures (170-185 cm and 24-28 cm, respectively), while Insanho 200 KLP, Insan 222 KLP, and Aluris KLP had intermediate values. These patterns indicate a tendency toward an association between vegetation duration and morphophysiological traits: shorter-cycle hybrids (Averno SU, Insanho 200 KLP) were more compact and resilient to environmental stress, whereas later-ripening hybrids (Lorys SLP, Aluris KLP) developed more biomass and larger heads, increasing productivity under sufficient water supply. This relationship requires further quantitative verification.

Yield, oil content, husk content and protein content in kernel of the sunflower hybrids

The data in Table 2 demonstrated a clear differentiation of the studied hybrids according to productive characteristics. The maximum seed yield indicators were recorded in the hybrid Lorys SLP (4.6-5.0 t/ha), which were due to its morphological features – large head size and high plant height. Aluris KLP had the highest oil content (52-54 %) and the highest oil yield per unit area (2.29-2.59 t/ha). The hybrid Insan 222 KLP showed balanced indicators, occupying an intermediate position in both parameters. Visualisation in the form of a scatterplot emphasised the specialisation of the hybrids: Lorys SLP as the leader in seed yield, Aluris KLP in oil content, and the other hybrids with different ratios of these traits

It was established that the hybrids Aluris KLP (20-22%) and Insan 222 KLP (21-23%), were characterised by the lowest husk content, which reduced the specific weight of waste during processing and increased kernel yield (Table 2). At the same time, these hybrids were distinguished by an increased protein content in the kernel (41-43% and 40-42% respectively), which increased the fodder value of processing by-products (Table 2). The obtained results indicate the need to take into account the qualitative characteristics of the seed when choosing a hybrid for a specific target use.

Tolerance / resistance of sunflower hybrids to abiotic and biotic stress factors

The study of the level of tolerance of the sunflower hybrids to abiotic stress factors revealed considerable differentiation in drought resistance and water-use efficiency indicators. The data in Table 3 demonstrated that the hybrids Insanho 200 KLP and Averno SU had the highest indicators of drought resistance and water-use efficiency, which were determined by a well-developed root system capable of effectively absorbing moisture from deep soil horizons. These hybrids also showed high heat resistance, which allowed maintaining productivity under conditions of air and soil drought. The other studied hybrids demonstrated an average level

of adaptation to abiotic stress factors, which limited the use under rainfed farming conditions. The hybrid Insan 222 KLP demonstrated a high level of resistance to phomopsis (*Phomopsis helianthi*). The hybrids Lorys SLP and Aluris KLP were distinguished by complex resistance to a wide range of pathogens, including powdery mildew (*Erysiphe cichoracearum*) and Grey mould (Table 3) which made these hybrids promising for cultivation in zones with increased infection pressure. The data in Table 3 confirmed the high resistance of all the studied hybrids to races A-G of sunflower broomrape (*Orobancha cumana*), which is critically important for a region with a high infection background.

CONCLUSIONS

The investigation confirmed that hybrid selection is a key factor for stabilizing sunflower productivity under the dry conditions of the Southern Steppe of Ukraine. Lorys SLP may be recommended for high seed yield, Aluris KLP for maximum oil output, and Averno SU or Insanho 200 KLP for rainfed conditions requiring stronger drought tolerance. For farms exposed to high disease pressure, Insan 222 KLP, Lorys SLP, and Aluris KLP are promising due to their resistance to major pathogens and broomrape races A-G. Future research should test these hybrids under different sowing dates, fertilization regimes, and moisture-management strategies to refine region-specific cultivation recommendations.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1: Maturity group, duration of vegetation, Plant height, Head diameter of the studied sunflower hybrids (average for 2022-2024)

Hybrid	Maturity group	Duration of vegetation period (days)	Plant height (cm)	Head diameter (cm)	C.D. Value (at 5% significance)
Averon SU	Mid-season	109-115	145-160	18-22	5.12
Insanho 200 KLP	Late-maturing	120-125	155-170	20-24	5.09
Insan 222 KLP	Mid-season	109-115	160-175	21-25	4.95
Lorys SLP	Medium-early	105-107	170-185	24-28	5.23
Aluris KLP	Late-maturing	120-125	165-180	22-26	5.15

Table 2: Yield, oil content, husk content and protein content in kernel of the studied hybrids (average for 2022-2024)

Hybrid	Seed yield (t/ha)	Oil content (%)	Oil yield, (t/ha)	Husk content (%)	Protein content in kernel (%)	C.D. Value (at 5% significance)
Averon SU	3.8-4.2	48-50	1.82-2.10	24-26	38-40	0.18
Insanho 200 KLP	4.0-4.4	49-51	1.96-2.24	23-25	39-41	0.16
Insan 222 KLP	4.2-4.6	50-52	2.1-2.39	21-23	40-42	0.17
Lorys SLP	4.6-5.0	48-50	2.21-2.50	24-26	38-40	0.19
Aluris KLP	4.4-4.8	52-54	2.29-2.59	20-22	41-43	0.18

Table 3: Level of tolerance / resistance of sunflower hybrids to abiotic and biotic stress factors (average for 2022-2024)

Hybrid	Drought resistance	Heat resistance	Water-use efficiency	Phomopsis	Powdery mildew	Grey mould	Sunflower broomrape (races A-G)
Averon SU	High	High	High	Medium	Medium	Medium	High
Insanho 200 KLP	High	Medium	High	Medium	High	Medium	High
Insan 222 KLP	Medium	High	Medium	High	High	Medium	High
Lorys SLP	Medium	Medium	Medium	High	High	High	High
Aluris KLP	Medium	High	Medium	High	High	High	High