

SUNFLOWER PRODUCTION OF SOME GENOTYPES IN YEARS 2022, 2023 AND 2024, IN ROMANIA

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Abstract

In this paper we present results about seed yield of some sunflower genotypes in the period 2022-2024, in nine counties from Romania. Three genotypes belonging to NARDI Fundulea were analysed, two experimental sunflower hybrids HS 1112 and HS9233 and one commercial sunflower hybrid FD15E27. In year 2023 was registered the best average seed yield of all three sunflower hybrids of 3189 kg/ha followed by year 2022 with 2930 kg/ha and the lowest average seed yield was registered in year 2024 with 2310 kg/ha. Experimental sunflower hybrid HS9233 which is suitable for Clearfield Plus system, registered the highest seed yield of 3045 kg/ha in year 2022 and 3241 kg/ha in year 2023. In year 2024, commercial sunflower hybrid FD15E27 registered the highest seed yield with 2417 kg/ha which is suitable for Express system. The agricultural year 2024 remains representative for the sunflower culture regarding lowest seed yield, because the climate changes were most evident through very high temperatures during the summer.

Key words: sunflower, seed yield, drought, extreme heat.

INTRODUCTION

In Romania in last years, sunflower (*Helianthus annuus* L.) is main oil crop and were cultivated on surface over 1 million hectares (Soare & Chiurciu, 2023). In 2022 were cultivated on 1.093 million hectares with an average seed yield of 1927 kg/ha and total production of 2.1 million tons. In 2023 were cultivated on 1.077 million hectares with an average seed yield of 1870 kg/ha and total production of 2.0 million tons. In 2024 were cultivated on 1.332 million hectares with an average seed yield of 993 kg/ha and total production of 1.3 million tons (MADR, Revista Ferma, Economica, EUROSTAT). Although sunflower has tolerance to water and heat stress conditions (Agüera & de la Haba, 2021; Markulj Kulundžić et al., 2022), seed yield of sunflower is affected by heat and drought (Anton et al., 2024; Beteri et al., 2024; Gurkan et al., 2021). In sunflower culture, high temperatures affect pollen viability and pollination (Astiz & Hernández, 2013; Mehmood et al., 2023; Moroldo et al., 2024). In sunflower culture, climate changes thought variation in temperature and precipitation affect

directly production and period of vegetation (Gurkan, 2023; Popescu et al., 2023). Sunflower production is depending on climatic conditions such temperature and precipitations (Cojocaru et al., 2023; Partal, 2022).

MATERIALS AND METHODS

In period 2022-2024, we tested three sunflower hybrids, HS 1112, HS 9233 and FD 15E27 belonging to NARDI Fundulea, in nine counties, Dolj, Bihor, Braila, Vaslui, Timis, Buzau, Telorman, Galati and Calarasi from Romania. HS1112 is experimental oil sunflower hybrid for and is suitable for conventional system and for organic system. HS 9233 is experimental oil sunflower hybrid resistant at Imidazoline herbicides and is suitable for Clearfield Plus system. FD15E27 is commercial oil sunflower hybrid resistant at sulfonyleurea herbicides and is suitable for Express system.

RESULTS AND DISCUSSIONS

Average annual temperature on country was in Romania, 10.64°C in year 2022, 11.38°C in year

2023 and 11.62⁰C in year 2024 (Figure 1). In terms of the average annual temperature ⁰C in Romania, 2024 was the warmest in the last 60 years, followed by 2023 and 2022 was in fifth place (Table 1).

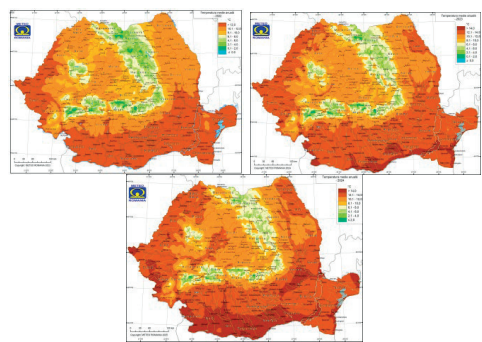


Figure 1. Average annual temperature in years 2022, 2023 and 2024, in Romania (source: www.meteoromania.ro)

In terms of the average annual temperature ⁰C in Romania, 2024 was the warmest in the last 60 years, followed by 2023 and 2022 was in fifth place (Table 1). Rising temperatures can affect the growth and yield of sunflowers. Sunflowers thrive in warm conditions, but excessively high temperatures can lead to heat stress, reducing seed yield.

Table 1. Average annual temperature in Romania (source: www.meteoromania.ro)

Top hottest years	Year	Average annual temperature (°C)
1	2024	11.62
2	2023	11.38
3	2019	11.00
4	2020	10.78
5	2022	10.64
6	2015	10.58
7	2018	10.53
8	2007	10.48
9	2014	10.35
10	1994	10.24

Total average of rainfalls on country registered in Romania in year 2022 was 553.2 mm, in year 2023 was 661.3 mm and in year 2024 was 551.4 mm (Figure 2). Regarding rainfalls, years 2022 and 2023 are characterized as drought years and 2024 as normal. Changes in rainfall patterns can result in droughts. Sunflowers require a certain

amount of water for optimal growth, so drought can affect production and can lead to reduced seed size and can lead to reduced sunflower seed yield.

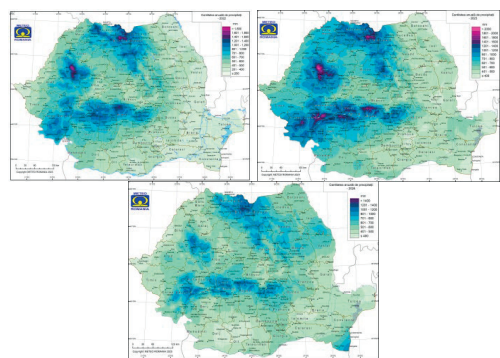


Figure 2. Total average rainfalls registered in years 2022, 2023 and 2024 in Romania (source: www.meteoromania.ro)

Availability and management of water resources are crucial, especially in regions prone to drought.

Variability in rainfall, temperature, and sunlight can significantly impact sunflower crop growth. In year 2022, average seed yield on counties was between 1674 kg/ha in Bihor and 3721 kg/ha in Galati (Table 2). In year 2022, average seed yield of sunflower hybrids was between 2735 kg/ha at HS1112 and 3045 kg/ha at HS9233.

Table 2. Average seed yield of sunflower genotypes registered in year 2022, in nine counties from Romania

County	Average seed yield (kg)			
	HS1112	HS9233	FD15E27	Average
Dolj	3364	3979	3545	3629
Bihor	1605	1760	1659	1674
Braila	1281	2571	1779	1877
Vaslui	2498	3092	3785	3125
Timis	2373	2135	2322	2276
Buzau	3486	3267	2941	3231
Telorman	3288	3293	3690	3423
Galati	3326	3848	3991	3721
Calarasi	3395	3465	3380	3413
Average	2735	3045	3010	2930

In year 2022, one thousand seed weight (TSW g) on counties was between 45 g in Bihor and 66 g in Galati (Table 3). In year 2022, average one thousand seed weight (TSW g) of sunflower hybrids was between 52 g at FD15E27 and 64 g at HS9233.

Table 3. Average one thousand seed weight (TSW g) of sunflower genotypes registered in year 2022, in nine counties from Romania

County	TSW (g)			
	HS1112	HS9233	FD15E27	Average
Dolj	63	80	50	64
Bihor	39	50	46	45
Braila	71	72	54	65
Vaslui	54	61	47	54
Timis	52	61	61	58
Buzau	52	66	57	58
Telorman	52	62	50	54
Galati	71	72	56	66
Calarasi	60	53	55	56
Average	57	64	52	57

In year 2022, hectolitre weight (HW kg/hl) on counties was between 36 kg/hl in Calarasi and 42 kg/hl in Telorman (Table 4). In year 2022, average hectolitre weight (HW kg/hl) of sunflower hybrids was between 38 kg/hl at FD15E27, HS9233 and 40 kg/hl at HS1112.

Table 4. Average hectolitre weight (HW kg/hl) of sunflower genotypes registered in year 2022, in nine counties from Romania

County	Hectolitre weight (kg/hl)			
	HS1112	HS9233	FD15E27	Average
Dolj	40	39	40	39
Bihor	39	38	40	39
Braila	42	39	36	39
Vaslui	39	39	39	39
Timis	39	39	39	39
Buzau	40	38	38	38
Telorman	43	42	43	42
Galati	44	40	38	40
Calarasi	36	35	37	36
Average	40	38	38	39

In year 2022, average height (cm) of sunflower hybrids was between 133 cm at HS1112 and 143 cm at HS9233. In year 2022, height (cm) on counties was between 106 cm in Bihor and 168 cm in Dolj (Table 5).

Table 5. Average height (cm) of sunflower genotypes registered in year 2022, in nine counties from Romania

County	Height (cm)			
	HS1112	HS9233	FD15E27	Average
Dolj	165	175	165	168
Bihor	113	110	95	106
Braila	114	162	135	137
Vaslui	150	160	137	149
Timis	104	116	147	122
Buzau	125	130	125	126
Telorman	147	140	133	140
Galati	138	160	147	148
Calarasi	145	135	160	146
Average	133	143	138	138

In year 2022, average period of vegetation (days) of sunflower hybrids was between 115 days at HS1112 and FD15E27 and 116 days at HS9233. In year 2022, period of vegetation

(days) on counties was between 108 days in Timis and 127 days in Braila (Table 6).

Table 6. Average period of vegetation (days) of sunflower genotypes registered in year 2022, in nine counties from Romania

County	Period of vegetation (days)			
	HS1112	HS9233	FD15E27	Average
Dolj	113	113	113	113
Bihor	117	117	117	117
Braila	126	130	126	127
Vaslui	120	120	118	119
Timis	108	108	108	108
Buzau	122	121	117	120
Telorman	108	111	109	109
Galati	121	122	122	121
Calarasi	106	109	113	109
Average	115	116	115	115

In year 2023, average seed yield on counties were between 2242 kg/ha in Vaslui and 4056 kg/ha in Galati (Table 7). In year 2023, average seed yield of sunflower hybrids was between 3104 kg/ha at FD15E27 and 3241 kg/ha at HS9233.

Table 7. Average seed yield of sunflower genotypes registered in year 2023, in nine counties from Romania

County	Average seed yield (kg)			
	HS1112	HS9233	FD15E27	Average
Dolj	3483	3318	3316	3372
Bihor	3472	3737	3457	3555
Braila	3053	3422	2520	2998
Vaslui	2056	2169	2501	2242
Timis	3602	3273	3466	3447
Buzau	3190	3307	2887	3128
Telorman	2409	2242	2492	2381
Galati	4588	4057	3523	4056
Calarasi	3152	3647	3774	3524
Average	3222	3241	3104	3189

In year 2023, one thousand seed weight (TSW g) on counties was between 39 g in Teleorman and 65 g in Timis (Table 8). In year 2023, average one thousand seed weight (TSW g) of sunflower hybrids was between 50 g at HS1112 and 65 g at HS9233.

Table 8. Average one thousand seed weight (TSW g) of sunflower genotypes registered in year 2023, in nine counties from Romania

County	TSW (g)			
	HS1112	HS9233	FD15E27	Average
Dolj	64	60	45	56
Bihor	45	64	52	53
Braila	54	72	57	61
Vaslui	58	54	74	62
Timis	47	84	66	65
Buzau	48	64	55	55
Telorman	32	46	41	39
Galati	54	70	57	60
Calarasi	51	72	65	62
Average	50	65	56	57

In year 2023, hectolitre weight (HW kg/hl) on counties was between 36 kg/hl in Vaslui and Buzau and 42 kg/hl in Timis and Calarasi (Table 9). In year 2023, average hectolitre weight (HW kg/hl) of sunflower hybrids was between 38 kg/hl at HS9233 and 39 kg/hl at HS1112 and FD15E27.

Table 9. Average hectolitre weight (HW kg/hl) of sunflower genotypes registered in year 2023, in nine counties from Romania

County	Hectolitre weight (kg/hl)			
	HS1112	HS9233	FD15E27	Average
Dolj	40	39	41	40
Bihor	41	39	39	39
Braila	39	39	38	38
Vaslui	36	36	37	36
Timis	44	39	43	42
Buzau	38	36	36	36
Telorman	39	40	43	40
Galati	38	39	37	38
Calarasi	42	42	42	42
Average	39	38	39	39

In year 2023, average height (cm) of sunflower hybrids was between 131 cm at HS1112 and 168 cm at HS9233. In year 2023, height (cm) on counties was between 121 cm in Braila and 181 cm in Dolj (Table 10).

Table 10. Average height (cm) of sunflower genotypes registered in year 2023, in nine counties from Romania

County	Height (cm)			
	HS1112	HS9233	FD15E27	Average
Dolj	155	215	175	181
Bihor	134	157	153	148
Braila	100	140	125	121
Vaslui	134	170	161	155
Timis	155	193	173	173
Buzau	120	160	135	138
Telorman	127	156	145	142
Galati	140	180	165	161
Calarasi	119	158	130	135
Average	131	168	151	150

In year 2023, average period of vegetation (days) of sunflower hybrids was between 105 days at HS1112 and 107 days at HS9233. In year 2023, period of vegetation (days) on counties was between 95 days in Teleorman and 131 days in Braila (Table 11).

Table 11. Average period of vegetation (days) of sunflower genotypes registered in year 2023, in nine counties from Romania

County	Period of vegetation (days)			
	HS1112	HS9233	FD15E27	Average
Dolj	102	105	102	103
Bihor	111	111	111	111
Braila	133	131	131	131
Vaslui	97	100	98	98

Timis	99	103	104	102
Buzau	116	115	115	115
Telorman	92	97	97	95
Galati	100	100	100	100
Calarasi	102	104	103	103
Average	105	107	106	106

In year 2024, average seed yield on counties were between 1137 kg/ha in Teleorman and 3134 kg/ha in Timis (Table 12). In year 2024, average seed yield of sunflower hybrids was between 2162 kg/ha at HS2162 and 24171 kg/ha at FD15E27.

Table 12. Average seed yield of sunflower genotypes registered in year 2024, in nine counties from Romania

County	Average seed yield (kg)			
	HS1112	HS9233	FD15E27	Average
Dolj	1412	1891	2158	1820
Bihor	2000	2178	2115	2097
Braila	2932	3258	2990	3060
Vaslui	2671	2959	2654	2761
Timis	3095	3088	3220	3134
Buzau	1620	1819	1629	1689
Telorman	1089	1082	1242	1137
Galati	2353	2677	2883	2637
Calarasi	2292	2224	2865	2460
Average	2162	2352	2417	2310

In year 2024, one thousand seed weight (TSW g) on counties was between 30 g in Teleorman and 63 g in Timis (Table 13). In year 2024, average one thousand seed weight (TSW g) of sunflower hybrids was between 42 g at HS1112 and 53 g at HS9233.

Table 13. Average one thousand seed weight (TSW g) of sunflower genotypes registered in year 2024, in nine counties from Romania

County	TSW (g)			
	HS1112	HS9233	FD15E27	Average
Dolj	43	57	54	51
Bihor	38	46	46	43
Braila	48	70	56	58
Vaslui	41	43	46	43
Timis	63	58	68	63
Buzau	37	42	37	38
Telorman	25	32	33	30
Galati	44	55	56	51
Calarasi	46	75	63	61
Average	42	53	51	48

In year 2024, hectolitre weight (HW kg/hl) on counties was between 35 kg/hl in Bihor and Telorman and 41 kg/hl in Dolj and Timis (Table 14). In year 2024, average hectolitre weight (HW kg/hl) of sunflower hybrids was between 37 kg/hl at HS1112 and HS9233 and 39 kg/hl at FD15E27.

Table 14. Average hectolitre weight (HW kg/hl) of sunflower genotypes registered in year 2024, in nine counties from Romania

County	Hectolitre weight (kg/hl)			
	HS1112	HS9233	FD15E27	Average
Dolj	41	42	41	41
Bihor	37	34	36	35
Braila	39	40	41	40
Vaslui	37	37	39	37
Timis	38	42	43	41
Buzau	38	35	36	36
Telorman	33	35	39	35
Galati	37	38	40	38
Calarasi	38	38	43	39
Average	37	37	39	38

In year 2024, average height (cm) of sunflower hybrids was between 129 cm at HS1112 and 149 cm at HS9233. In year 2024, height (cm) on counties was between 95 cm in Teleorman and 175 cm in Vaslui (Table 15).

Table 15. Average height (cm) of sunflower genotypes registered in year 2024, in nine counties from Romania

County	Height (cm)			
	HS1112	HS9233	FD15E27	Average
Dolj	120	175	170	155
Bihor	90	112	104	102
Braila	144	174	147	155
Vaslui	160	185	180	175
Timis	163	139	141	147
Buzau	162	150	140	150
Telorman	93	90	102	95
Galati	115	160	120	131
Calarasi	115	162	135	137
Average	129	149	137	138

In year 2024, average period of vegetation (days) of sunflower hybrids was between 113 days at HS1112 and HS9233 and 114 days at FD15E27. In year 2024, period of vegetation (days) on counties was between 96 days in Galati and 128 days in Braila (Table 16).

Table 16. Average period of vegetation (days) of sunflower genotypes registered in year 2024, in nine counties from Romania

County	Period of vegetation (days)			
	HS1112	HS9233	FD15E27	Average
Dolj	104	106	111	107
Bihor	123	123	124	123
Braila	128	128	128	128
Vaslui	112	113	117	114
Timis	108	110	114	110
Buzau	118	118	114	116
Telorman	105	105	104	104
Galati	97	96	97	96
Calarasi	123	123	122	122
Average	113	113	114	113

In period 2022-2024, average seed yield of sunflower hybrids in nine counties from

Romania were between 2706 kg/ha at HS1112 and 2879 kg/ha at HS9233 (Table 17). In year 2023, average seed yield of sunflower hybrids was the highest with 3189 kg/ha and year 2024 was the lowest with 2310 kg/ha.

Table 17. Average seed yield of sunflower genotypes registered in years 2022, 2023 and 2024

Sunflower genotype	Average seed yield (kg)			
	2022	2023	2024	Average
HS1112	2735	3222	2162	2706
HS9233	3045	3241	2352	2879
FD15E27	3010	3104	2417	2843
Average	2930	3189	2310	2809

Counties significantly influences seed yield, while genotype does not (Figure 3). Differences between sunflower genotypes are not statistically significant. The year significantly influences seed yield, meaning the differences in yield between 2022, 2023 and 2024 are statistically significant.

Environmental explain variations between counties and climate strongly influence seed yield.

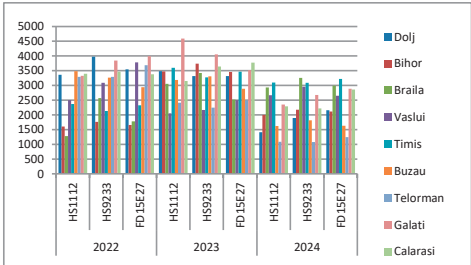


Figure 3. Average seed yield of sunflower genotypes registered in years 2022, 2023 and 2024 in nine counties from Romania

After analyzing the production of sunflower hybrids in nine counties, we created a map with the favorable areas for sunflower culture (Figure 4).

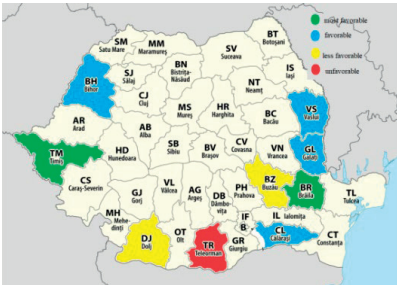


Figure 4. Favorable areas for sunflower culture in Romania

The most stable average hectolitre weight was at sunflower hybrid HS9233 in all years of studies (Figure 5). In year 2024 that was the hottest from last 60 years, the highest average hectolitre weight was registered by sunflower hybrid FD15E27.

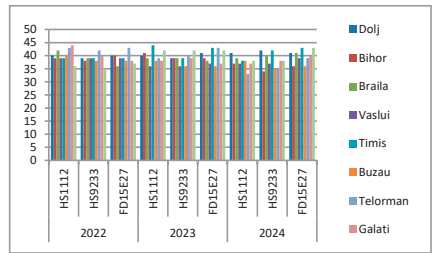


Figure 5. Average hectolitre weight (HW kg/hl) of sunflower genotypes registered in period 2022-2024

The highest average one thousand seed weight (TSW g) was registered by sunflower hybrid HS9233 in period 2022-2024 (Figure 6). Is a positive correlation between TSW and seed yield. If TSW increase, seed yield increase because heavier seeds lead to greater seed production.

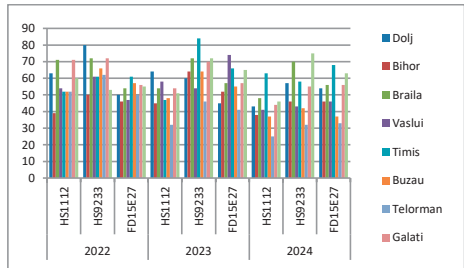


Figure 6. Average one thousand seed weight (TSW g) of sunflower genotypes registered in period 2022-2024

Average plant height (cm) was variable each year and in each county (Figure 7) with the highest records in 2023.

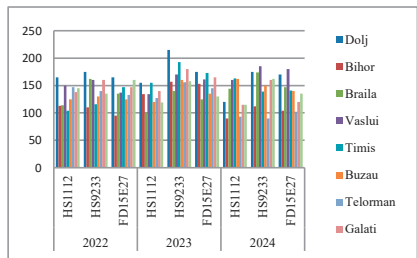


Figure 7. Average plant height (cm) of sunflower genotypes registered in period 2022-2024, in nine counties from Romania

In county Braila was registered the highest period of vegetation in all three years of study (Figure 8).

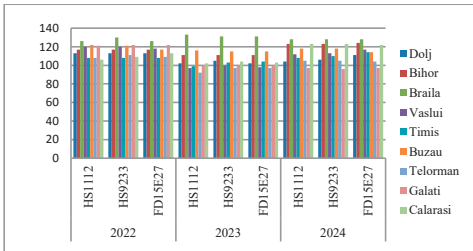


Figure 8. Average period of vegetation (days) of sunflower genotypes registered in period 2022-2024

Factors county (A), year (B), sunflower hybrid (C) and interaction between these factors influenced very significant positive seed yield (kg/ha), one thousand seed weight (TSW g), hectolitre weight (HW kg/hl) and plant height (cm) of sunflower hybrids (Tables 18-21).

Table 18. ANOVA analysis of variance for seed yield (kg/h) of sunflower hybrids in nine locations from Romania, in years 2022, 2023 and 2024

Source	Degrees of Freedom	Sum of Squares	Mean Square	F value	Signification
Factor A	8	27790874.519	3473859.315	310.8284	***
Factor B	2	31245466.691	15622733.346	1397.8659	***
AB	16	72924148.346	4557759.272	407.8119	***
Error	52	581158.864	11176.132		
Factor C	2	1356078.321	678039.160	33.6622	***
AC	16	4853226.494	303326.656	15.0591	***
BC	4	1284069.432	321017.358	15.9374	***
ABC	32	6024126.864	188253.965	9.3461	***
Error	108	2175384.222	20142.447		

Table 19. ANOVA analysis of variance for one thousand seed weight (TSW g) of sunflower hybrids in nine locations from Romania, in years 2022, 2023 and 2024

Source	Degrees of Freedom	Sum of Squares	Mean Square	F value	Signification
Factor A	8	7314.346	914.293	1362.7045	***
Factor B	2	2758.753	1379.377	2055.8861	***
AB	16	3525.802	220.363	328.4386	***
Error	26	17.444	0.671		
Factor C	2	3181.123	1590.562	606.2847	***
AC	16	13183765	82.423	31.4176	***
BC	4	985.802	246.451	93.9412	***
ABC	32	3193.975	99.812	38.0459	***
Error	54	141.667	2.623		

Table 20. ANOVA analysis of variance for hectolitre weight (HW kg/hl) of sunflower hybrids in nine locations from Romania, in years 2022, 2023 and 2024

Source	Degrees of Freedom	Sum of Squares	Mean Square	F value	Signification
Factor A	8	180.494	22.562	101.5278	***
Factor B	2	33.975	16.988	76.4444	***
AB	16	383.802	23.988	107.9444	***
Error	26	5.778	0.222		
Factor C	2	29.827	14.914	67.1111	***
AC	16	98.617	6.164	27.7361	***
BC	4	57.580	14.395	64.7778	***
ABC	32	127.309	3.978	17.9028	***
Error	54	12.000	0.222		

Table 21. ANOVA analysis of variance for plant height (cm) of sunflower hybrids in nine locations from Romania, in years 2022, 2023 and 2024

Source	Degrees of Freedom	Sum of Squares	Mean Square	F value	Signification
Factor A	8	35195.383	4399.423	1140.0498	***
Factor B	2	5717.049	2858.525	740.7473	***
AB	16	32755.951	2047.247	530.5158	***
Error	26	100.333	3.859		
Factor C	2	14538.235	7269.117	1872.1733	***
AC	16	4896.099	306.006	78.8124	***
BC	4	3824.321	956.080	246.2401	***
ABC	32	10328.346	322.761	83.1276	***
Error	54	209.667	3.883		

Factor A - County; Factor B - Year; Factor C - Sunflower hybrid; AB - Interaction between Factor County and Factor Year; AC - Interaction between Factor County and Factor Sunflower hybrid; BC - Interaction between Factor Year and Factor Sunflower hybrid; ABC - Interaction between Factor County and Factor Year and Factor Sunflower hybrid

CONCLUSIONS

The agricultural year 2023 was the most suitable for sunflower culture and year 2024 was the most unfavourable for sunflower culture do to extreme heat registered for a long period of time especially in period of flowering and seed filing. There are fluctuations in yields across the years, indicating varying agricultural conditions, including climate factors. Long-term shifts in weather patterns can alter growing seasons and affect the viability of sunflower crop in specific regions.

Different sunflower hybrid may have varying resilience to environmental stressors. The choice of cultivar can influence yield stability. Experimental sunflower hybrid HS9233, suitable for Clearfield Plus system were the most adapted for climate changes followed by sunflower hybrid FD15E27.

This data highlights the importance of monitoring agricultural yields over time to understand trends, challenges and opportunities for improvement in sunflower seed production.

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