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Effect of Alien Cytoplasm on Seed Yield and its Attributing Traits in Sunflower (*Helianthus annuus* L.)

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ABSTRACT

Diversification of the cytosterile base of sunflower requires utilization of alien cytoplasm in sunflower hybrid production but before incorporating them in breeding program, it is essential to study the impact of alien cytoplasm on seed yield and its attributing traits. In the present study the CMS analog ARG-2-1-2 *(H. argophyllus)* was significantly better than MUT2-8-3-2 *(H. annuus)* for 100 seed weight, volume weight, seed yield, oil content and oil yield while it performed on par to 234 from classical *(H. petiolaris)* PET-1 source for these traits. Similarily, hybrids *per se* performance based on ARG-2-1-2 cytoplasm were superior over MUT-2-8-3-2 cytoplasm based hybrids for days to 50 per cent flowering, head diameter, days to maturity, 100 seed weight, seed yield, oil content and oil yield. The differences in these CMS analogues could probably be attributed to the favourable cytoplasmic effect / nuclear interaction of ARG-2-1-2 cytosterile source over MUT-2-8-3-2 in both inbreds and hybrids.

Keywords : Sunflower, Cytoplasmic male sterility, Hybrids, Seed yield

SUNFLOWER (*Helianthus annuus* L.) is an important oilseed crop widely adopted and accepted for its high-quality edible oil. It was introduced to India during 1969 from Russia in view of its distinct advantages, *viz.,* photo insensitivity, short duration, high seed multiplication ratio, high seed yield and better quality of oil. Sunflower hybrids are preferred over varieties because of their agronomic and economic advantages over them (Nehru *et al*., 2000). The favourable characters of sunflower hybrids including high productivity, response to high input agriculture, high self-fertility, uniform growth and maturity shifted the focus towards heterosis breeding. The synthesis of hybrids with high heterotic effect became possible after the discovery of the first cms source (Leclercq, 1969) and subsequent detection of fertility restoration genes (Kinman, 1970) that gave the required impetus to commercial hybrid seed production leading to the release of first ever sunflower hybrid BSH 1 in India (Seetharam, 1980), which provided required thrust to expand sunflower cultivation in the country. Since then, many hybrids have been released for commercial cultivation based on cytoplasmic genetic male sterility system.

Most of the commercial hybrid production in sunflower are based on PET 1 cytoplasm resulting in the genetic uniformity for the cytoplasmic back ground in the crop. Prevalence of genetic uniformity of this kind over a large area could result in genetic vulnerability of hybrids which can be avoided by using different cytosterile sources in hybrid production. One of the practical solution to widen the cytoplasmic base of the crop is the development of sterile CMS analogues of lines used in sunflower breeding. Seiler *et al*., 2017 reported that as many as 72 CMS sources have been developed in sunflower by intraspecific and interspecific crosses, which resulted in several CMS sources being available. Utilization of these CMS sources requires development of lines having different cytoplasms in common nuclear genetic background (isonuclear alloplasmic lines) in order to understand the impact of alien cytoplasm onseed yield and its contributing traits. Even in hybrids differing in their cytosterilitya thorough understanding of the interaction

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between alien cytoplasm and nuclear genes from commercially cultivated source and the impact of this interaction on heterosis for yield-related traits is required for utilizing these alloplasmic lines in hybrid development. Keeping this in mind, present study was conducted to compare *per se* performance of alloplasmic lines and hybrids having cytosterile sources from *H. argophyllus* and *H. annuus* in common nuclear genetic background.

Material and Methods

Isonuclear alloplasmic lines in 234 nuclear genetic background were developed by repeated back crossing for six generations with 234 as recurrent parent and *H. argophyllus, H. annuus* and *H. petiolaris* as cytosterile donor parent to compare them for their *per se* performance of seed yield and its component traits. These alloplasmic lines derived from *Helianthus argophyllus* (ARG 2-1-2) and *H. annuus* (MUT 2-8-3-2), were crossed with ten restorers *viz*., GKVK-3, RHA 6D-1, RHA 95-C-1, LTRR 822, M-17R, MR-1, RHA-272-II, X-15-NB-10, GKVK 2 and RHA 93 to obtain 20 experimental hybrids. Hybrids along with isonuclear alloplasmic lines were evaluated in *kharif* 2016 and *rabi / summer* 2016-17 with two replications each and experiment was laid out in randomized block design. Each genotype was represented by single row of 3.0 meter length with a spacing of 60 cm between rows and 30 cm between plants. Observations were recorded in each entry on randomly selected five plants for characters *viz*. days to 50 per cent flowering, plant height (cm), stem diameter (cm), head diameter (cm), days to maturity, seed filling (%), 100 seed weight, hull content (%), volume weight (g/100ml), seed yield (kg/ha) and oil content (%) and oil yield (kg/ha). Significance of differences between isonuclear alloplasmic lines for their *per se* performance was determined using CD which was computed as :

$$CD = \sqrt{(MSe/r)} \times \text{'t' table value at error df at } P = 0.05 \text{ \& } 0.01 \times \sqrt{2}$$

Paired 't' test was used to test the significance of differences among hybrids for their *per se* performance. Significance of differences among hybrids for their *per se* performance was considered as an evidence for the presence of cytoplasmic effects on hybrid mean performance.

Results and Discussion

Comparison of *per se* Performance of Isonuclear Alloplasmic Lines for Seed Yield and its Contributing Traits

The results indicated that for days to 50 per cent flowering, the *per se* performance of inbreds were significantly different (Table 1) as inbreds based on MUT-2-8-3-2 cytoplasm flowered earlier (54.5 days) compared to PET 1(56.0 days) and ARG-2-1-2 (58.0 days) while tested inbreds were on par for characters *viz.* plant height, head diameter, stem diameter and seed filling per cent. With reference to 100 seed weight inbreds based on CMS ARG-2-1-2 (4.71 g) had significantly higher seed weight than MUT-2-8-3-2 (4.22 g) and was on par with PET 1 (4.50 g). Inbreds based on MUT2-8-3-2 (41.57 g) recorded significantly lower volume weight as compared to ARG-2-1-2 (45.80 g) and PET 1 (46.90 g) which were at par with each other. With reference to seed yield

Table 1

Comparison of *per se* performance of alloplasmic lines with 234 nuclear genetic background for seed yield and its contributing traits

Character	*Per se* performance of alloplasmic lines under 234 nuclear background			
	ARG -2-1-2	MUT -2-8-3-2	PET-1	CD @ P=0.05
Days to 50 % flowering	58.0	54.5	56.0	1.41
Plant height (cm)	144.48	133.97	138.11	13.14
Head diameter (cm)	13.11	11.84	12.96	2.12
Stem diameter (cm)	1.96	1.87	1.93	0.23
Days to maturity	88.75	86.25	86.25	3.99
100 seed weight (g)	4.71	4.22	4.50	0.48
Volume weight (g/100ml)	45.80	41.57	46.90	2.19
Seed yield (kg/ha)	973.12	669.71	889.07	126.66
Hull content (%)	28.27	25.30	25.54	1.40
Seed filling per cent	94.00	93.58	93.11	2.52
Oil content (%)	36.69	35.11	36.64	1.36
Oil yield (kg/ha)	357.51	235.27	325.76	51.56

inbreds based on ARG-2-1-2 (973.12 kg/ha) and PET 1 (889.07 kg / ha) were on par but were significantly higher yielder than MUT2-8-3-2 (669.71 kg/ha). For oil content tested inbreds with cytoplasmic sources ARG-2-1-2 (36.69%) and PET-1 (36.64%) were on par but were significantly better than MUT2-8-3-2 (35.11 %). Similarily for oil yield inbreds based on MUT 2-8-3-2 (235.27 kg / ha) were significantly low yielder than ARG-2-1-2 (357.51kg / ha) and PET-1 (325.76 kg / ha).

The present results indicated the presence of influence of male sterility inducing cytoplasm on the expression of inbreds for overall *per se* performance. The CMS analog ARG-2-1-2 (*H. argophyllus*) was significantly better than MUT2-8-3-2 (*H. annuus*) for 100 seed weight, volume weight, seed yield, oil content and oil yield while it performed on par to 234 from classical (*H. petiolaris*) PET-1 source for these traits indicating that this inbred line derived from new cytoplasmic male sterility sources can be a substitute of the classical (PET-1) source. Similar inferences were also derived from the studies of Shankar *et al*. (2006); Tyagi & Dhillon (2017) and Sharma & Shadakshari (2021).

Comparison of *per se* Performance of Alloplasmic Hybrids

The cytoplasm showed significant influence on the performance of hybrids for days to 50 per cent flowering (Table 2) and days to maturity (Table 4) which was evident from significant differences between overall means. Hybrids based on cytosterile source ARG-2-1-2 not only flowered significantly earlier (56.60) but also matured early (87.88) when compared to MUT-2-8-3-2 based hybrids which is evident from the significant p value of <0.001. The significant differences between hybrids for days to 50 per cent flowering and days to maturity were present in six of the ten nuclear genetic backgrounds depicted that the cytoplasm did have significant influence on *per se* performance for earliness in sunflower.

TABLE 2

Comparison of *per se* performance of hybrids based on two cytosterile sources (ARG-2-1-2 & MUT-2-8-3-2) for days to 50 per cent flowering and plant height

Nuclear genetic background	Days to 50% flowering					Plant height (cm)				
	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value
ARG-2-1-2 /MUT-2-8-3-2 x GKVK-3	59.75	61.50	-1.75	2.049	0.131	164.00	166.13	-2.13	0.188	0.862
ARG-2-1-2/MUT-2-8-3-2 x RHA 6D-1	57.25	60.25	-3.00	2.324	0.103	166.00	170.80	-4.80	0.367	0.738
ARG-2-1-2/MUT-2-8-3-2 x RHA 95-C-1	58.00	59.25	-1.25	2.611	0.079	179.50	177.88	1.63	0.292	0.789
ARG-2-1-2/MUT-2-8-3-2 x LTRR-822	58.25	59.25	-1.00	1.225	0.308	168.10	170.80	-2.70	1.581	0.212
ARG-2-1-2/MUT-2-8-3-2 x M-17-R	56.25	54.50	1.75	2.333	0.102	152.35	155.60	-3.25	0.824	0.470
ARG-2-1-2/MUT-2-8-3-2 x MR-1	55.75	57.00	-1.25	5.00	0.015	169.40	157.60	11.80	3.038	0.056
ARG-2-1-2/MUT-2-8-3-2 x RHA 272-II	55.75	57.50	-1.75	1.698	0.188	164.20	170.00	-5.80	0.889	0.439
ARG-2-1-2/MUT-2-8-3-2 x X-15-NB-10	57.00	58.00	-1.00	2.449	0.092	173.00	161.05	11.95	1.785	0.172
ARG-2-1-2/MUT-2-8-3-2 x GKVK-2	53.50	60.00	-6.50	10.07	0.002	170.68	173.10	-2.42	0.262	0.810
ARG-2-1-2/MUT-2-8-3-2 x RHA-93	54.50	57.00	-2.50	2.611	0.079	148.38	156.08	-7.70	0.903	0.433
Mean	56.60	58.43	-1.83	4.735	<0.001	165.56	165.90	-0.34	0.143	0.887

For plant height the non-significant differences ($p>0.05$) between hybrids across all nuclear genetic backgrounds (Table 2) depicted that the cytoplasm did not have significant influence on *per se* performance for plant height. Overall mean of the hybrids for head diameter (Table 3) based on cytosterile source ARG-2-1-2 (14.24 cm) was significantly higher than the MUT-2-8-3-2 (13.89 cm) based hybrids as indicated by $p<0.05$. But except in one nuclear genetic background in all other hybrids based on these two cytosterile sources were on par with each other. However cytoplasm did had significant influence on *per se* performance for head diameter. Among the ARG-2-1-2 hybrids, stem diameter ranged from 2.08 cm to 2.37 cm while it ranged from 2.12 cm to 2.44 cm among the MUT-2-8-3-2 hybrids. For this trait the overall means of the hybrids based on ARG-2-1-2 was 2.265 cm while those based on MUT-2-8-3-2 was 2.260 cm with $p>0.005$ indicating that diverse cytosterilie source were on par and differed only in GKVK 3 and MR 1 nuclear genetic background.

The *per se* performance of hybrids differed significantly for 100 seed weight. The significant differences between the means were observed in five nuclear genetic backgrounds (Table 4). The male sterile cytoplasm ARG-2-1-2 based hybrids, manifested high 100 seed weight (5.14g) compared to MUT-2-8-3-2 based hybrids (4.82g) indicating cytoplasmic influence on this important yield contributing trait. For volume weight none of the 10 nuclear genetic backgrounds registered significant differences for *per se* performance between ARG-2-1-2 and MUT-2-8-3-2 based hybrids (Table 5).

In the present study seed yield ranged from 1745.69 kg / ha (ARG-2-1-2 x M-17-R) to 2369.30 kg / ha (ARG-2-1-2 x LTRR-822) for ARG-2-1-2 cytosterile source while it ranged from 1609.58 kg / ha (MUT-2-8-3-2 x RHA 6D-1) to 2397.08 kg / ha (MUT-2-8-3-2 x GKVK-3) for MUT-2-8-3-2 basedhybrids (Table 5). Significant differences in *per se* performance for seed yield were observed

TABLE 3

Comparison of per se performance of hybrids based on two cytosterile sources (ARG-2-1-2 & MUT-2-8-3-2) for head diameter and stem diameter

Nuclear genetic background	Head diameter (cm)					Stem diameter (cm)				
	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value
ARG-2-1-2 /MUT-2-8-3-2 x GKVK-3	13.80	14.95	-1.15	9.139	0.003	2.29	2.44	-0.16	6.875	0.006
ARG-2-1-2/MUT-2-8-3-2 x RHA 6D-1	14.90	14.00	0.90	2.056	0.132	2.37	2.20	0.17	2.239	0.111
ARG-2-1-2/MUT-2-8-3-2 x RHA 95-C-1	14.75	13.85	0.90	2.635	0.078	2.33	2.38	-0.05	1.508	0.229
ARG-2-1-2/MUT-2-8-3-2 x LTRR-822	14.35	13.90	0.45	1.567	0.215	2.33	2.28	0.05	1.417	0.251
ARG-2-1-2/MUT-2-8-3-2 x M-17-R	13.35	13.08	0.28	1.616	0.205	2.20	2.12	0.09	2.573	0.082
ARG-2-1-2/MUT-2-8-3-2 x MR-1	14.30	13.63	0.68	1.362	0.267	2.37	2.28	0.09	3.416	0.042
ARG-2-1-2/MUT-2-8-3-2 x RHA 272-II	14.55	13.93	0.63	1.667	0.194	2.25	2.28	-0.03	0.547	0.622
ARG-2-1-2/MUT-2-8-3-2 x X-15-NB-10	14.00	14.20	-0.20	1.069	0.363	2.28	2.21	0.07	0.732	0.517
ARG-2-1-2/MUT-2-8-3-2 x GKVK-2	14.10	13.40	0.70	1.183	0.321	2.08	2.17	-0.09	2.111	0.125
ARG-2-1-2/MUT-2-8-3-2 x RHA-93	14.25	13.98	0.28	0.583	0.601	2.16	2.25	-0.09	2.109	0.126
Mean	14.24	13.89	0.35	2.444	0.019	2.265	2.260	0.005	0.247	0.806

TABLE 4

Comparison of per se performance of hybrids based on two cytosterile sources (ARG-2-1-2 & MUT-2-8-3-2) for days to maturity and 100 seed weight

Nuclear genetic background	Days to maturity					100 seed weight (g)				
	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value
ARG-2-1-2 /MUT-2-8-3-2 x GKVK-3	91.00	94.00	-3.00	7.348	0.005	5.25	5.45	-0.20	0.560	0.614
ARG-2-1-2/MUT-2-8-3-2 x RHA 6D-1	87.50	93.50	-6.00	5.196	0.014	5.60	4.29	1.31	7.686	0.005
ARG-2-1-2/MUT-2-8-3-2 x RHA 95-C-1	88.00	92.00	-4.00	3.098	0.053	5.74	5.28	0.46	4.221	0.024
ARG-2-1-2/MUT-2-8-3-2 x LTRR-822	90.00	90.25	-0.25	0.151	0.889	5.38	4.80	0.58	5.987	0.009
ARG-2-1-2/MUT-2-8-3-2 x M-17-R	86.00	87.75	-1.75	2.782	0.069	4.48	3.82	0.66	5.218	0.014
ARG-2-1-2/MUT-2-8-3-2 x MR-1	87.25	90.50	-3.25	3.434	0.041	4.67	4.63	0.04	0.216	0.842
ARG-2-1-2/MUT-2-8-3-2 x RHA 272-II	88.50	89.75	-1.25	0.620	0.579	5.41	5.26	0.15	1.442	0.245
ARG-2-1-2/MUT-2-8-3-2 x X-15-NB-10	89.25	90.50	-1.25	1.987	0.141	4.42	5.19	-0.77	9.121	0.003
ARG-2-1-2/MUT-2-8-3-2 x GKVK-2	85.25	92.00	-6.75	10.730	0.002	5.13	4.38	0.74	5.505	0.012
ARG-2-1-2/MUT-2-8-3-2 x RHA-93	86.00	91.00	-5.00	4.629	0.019	5.34	5.13	0.20	1.068	0.364
Mean	87.88	91.13	-3.25	7.072	<0.001	5.14	4.82	0.32	3.199	0.003

TABLE 5

Comparison of per se performance of hybrids based on two cytosterile sources (ARG-2-1-2 & MUT-2-8-3-2) for volume weight and seed yield

Nuclear genetic background	Volume weight (g/100ml)					Seed yield (kg/ha)				
	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value
ARG-2-1-2 /MUT-2-8-3-2 x GKVK-3	46.42	47.61	-1.19	0.789	0.488	1902.64	2397.08	-494.44	3.245	0.048
ARG-2-1-2/MUT-2-8-3-2 x RHA 6D-1	45.20	45.59	-0.39	0.287	0.792	1976.25	1609.58	366.67	5.955	0.010
ARG-2-1-2/MUT-2-8-3-2 x RHA 95-C-1	44.70	45.24	-0.55	0.382	0.728	2195.42	1977.64	217.78	0.811	0.476
ARG-2-1-2/MUT-2-8-3-2 x LTRR-822	42.63	43.81	-1.18	1.874	0.158	2369.30	1788.75	580.56	7.125	0.006
ARG-2-1-2/MUT-2-8-3-2 x M-17-R	47.23	46.99	0.24	0.160	0.883	1745.69	1512.36	233.33	3.117	0.053
ARG-2-1-2/MUT-2-8-3-2 x MR-1	45.26	47.22	-1.96	1.749	0.179	2019.30	2076.25	-56.94	1.170	0.326
ARG-2-1-2/MUT-2-8-3-2 x RHA 272-II	43.36	45.05	-1.69	1.237	0.304	2035.97	1810.97	225.00	3.067	0.055
ARG-2-1-2/MUT-2-8-3-2 x X-15-NB-10	39.46	39.91	-0.44	0.359	0.743	1885.97	1929.03	-43.06	0.421	0.702
ARG-2-1-2/MUT-2-8-3-2 x GKVK-2	46.89	44.94	1.95	1.075	0.361	2158.19	1679.03	479.17	8.436	0.003
ARG-2-1-2/MUT-2-8-3-2 x RHA-93	42.55	42.80	-0.25	0.098	0.928	2306.80	2269.30	37.50	0.310	0.777
Mean	44.37	44.91	-0.55	1.198	0.238	2059.55	1905.00	154.56	2.669	0.011

between hybrids in five nuclear genetic backgrounds. The overall mean of these two group of hybrids showed significant differences for seed yield with $p<0.05$ indicating the positive cytoplasmic effect / nuclear interaction in ARG -2-1-2 cytoplasm based hybrids compared to MUT-2-8-3-2 based counterparts.

Lower hull content is desired in the hybrids as it has negative impact on oil content. The *per se* performance of ARG-2-1-2 and MUT-2-8-3-2 based hybrids were comparable and they differed only in three nuclear genetic backgrounds (Table 6). The overall mean of the ARG-2-1-2 group of hybrids (28.28%) and their corresponding MUT-2-8-3-2 group of hybrids (29.06%) were comparable which is evident from non-significant difference between overall means indicating that both cytosterile sources were equally efficient for hull content. For seed filling percentage, six of the 10 nuclear genetic backgrounds registered significant differences for *per se* performance between hybrids differing in their male sterility cytoplasms. The ARG-2-1-2 based hybrids as a group did not show significant differences with their corresponding MUT-2-8-3-2 group of hybrids for seed filling percentage which is evident from non-significant difference between overall means of ARG-2-1-2 (92.38%) and MUT-2-8-3-2 (91.21%) based hybrids confirming that both the cytosterile sources were comparable for this trait.

The cytosterile source ARG-2-1-2 differed significantly with respect to it's *per se* performances for oil content in all the nuclear genetic back grounds. The ARG-2-1-2 group of hybrids and their corresponding MUT-2-8-3-2 group of hybrids manifested significant differences for oil content which is evident from significant difference between their overall means (Table 7). Further, ARG-2-1-2 group of hybrids showed superiority over MUT-2-8-3-2 group of hybrids. As oil yield is a derivative trait of oil content and seed yield, it is expected to have cytoplasmic influence on *per se* performance as for both these traits influence of cytosterilie sources were significant. On the

TABLE 6

Comparison of per se performance of hybrids based on two cytosterile sources (ARG-2-1-2 & MUT-2-8-3-2) for hull content and seed filling percentage

Nuclear genetic background	Hull content (%)					Seed filling percentage				
	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value
ARG-2-1-2 /MUT-2-8-3-2 x GKVK-3	28.69	26.78	1.90	1.852	0.161	91.76	94.80	-3.04	18.69	<0.001
ARG-2-1-2/MUT-2-8-3-2 x RHA 6D-1	28.16	29.76	-1.61	3.047	0.056	93.34	90.46	2.88	5.46	0.012
ARG-2-1-2/MUT-2-8-3-2 x RHA 95-C-1	27.24	28.80	-1.56	2.778	0.069	94.89	89.50	5.39	5.62	0.011
ARG-2-1-2/MUT-2-8-3-2 x LTRR-822	24.17	25.07	-0.90	2.156	0.120	95.18	91.16	4.01	13.31	<0.001
ARG-2-1-2/MUT-2-8-3-2 x M-17-R	29.06	26.30	2.77	2.359	0.099	92.70	85.74	6.97	14.90	<0.001
ARG-2-1-2/MUT-2-8-3-2 x MR-1	29.57	29.41	0.17	0.312	0.778	90.81	93.14	-2.33	13.71	<0.001
ARG-2-1-2/MUT-2-8-3-2 x RHA 272-II	31.74	34.58	-2.84	4.274	0.024	89.39	92.70	-3.30	1.83	0.165
ARG-2-1-2/MUT-2-8-3-2 x X-15-NB-10	30.79	33.91	-3.12	8.600	0.003	91.48	91.34	0.14	2.33	0.102
ARG-2-1-2/MUT-2-8-3-2 x GKVK-2	30.76	27.45	3.31	13.95	<0.001	88.88	90.17	-1.29	1.59	0.210
ARG-2-1-2/MUT-2-8-3-2 x RHA-93	22.65	28.56	-5.91	6.424	0.008	95.34	93.14	2.20	6.11	0.009
Mean	28.28	29.06	-0.78	1.625	0.112	92.38	91.21	1.16	1.960	0.057

TABLE 7

Comparison of per se performance of hybrids based on two cytosterile sources (ARG-2-1-2 & MUT-2-8-3-2) for oil content and oil yield

Nuclear genetic background	Oil content (%)					Oil yield (kg/ha)				
	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value	ARG-2-1-2	MUT-2-8-3-2	Diff.	t value	P value
ARG-2-1-2/MUT-2-8-3-2 x GKVK-3	35.55	32.18	3.37	6.41	0.008	676.87	772.48	-95.61	2.167	0.119
ARG-2-1-2/MUT-2-8-3-2 x RHA6D-1	38.81	29.82	8.99	31.00	<0.001	768.61	480.47	288.14	7.273	0.005
ARG-2-1-2/MUT-2-8-3-2 x RHA95-C-1	37.12	31.94	5.18	10.36	0.002	819.58	632.10	187.48	1.682	0.191
ARG-2-1-2/MUT-2-8-3-2 x LTRR-822	36.89	29.53	7.35	27.49	<0.001	876.03	529.13	346.90	8.403	0.004
ARG-2-1-2/MUT-2-8-3-2 x M-17-R	38.24	30.80	7.44	39.67	<0.001	668.22	466.96	201.26	6.866	0.006
ARG-2-1-2/MUT-2-8-3-2 x MR-1	38.58	30.43	8.15	50.14	<0.001	780.08	632.77	147.31	13.32	<0.001
ARG-2-1-2/MUT-2-8-3-2 x RHA272-II	34.67	29.88	4.80	7.73	0.005	706.98	543.92	163.06	6.777	0.007
ARG-2-1-2/MUT-2-8-3-2 x X-15-NB-10	37.61	30.19	7.43	17.07	<0.001	710.16	583.22	126.94	4.647	0.019
ARG-2-1-2/MUT-2-8-3-2 x GKVK-2	36.99	31.58	5.41	21.64	<0.001	798.75	531.14	267.61	11.73	0.001
ARG-2-1-2/MUT-2-8-3-2 x RHA-93	38.10	30.82	7.28	20.09	<0.001	879.74	700.71	179.03	4.20	0.025
Mean	37.25	30.72	6.54	22.77	<0.001	768.50	587.29	181.21	8.109	<0.001

expected lines ARG-2-1-2 group of hybrids and their corresponding MUT-2-8-3-2 group of hybrids manifested significant differences for oil yield which is evident from significant difference between overall means of ARG-2-1-2 (768.50 kg / ha) and MUT-2-8-3-2 (587.29 kg / ha) based hybrids confirming significant influence of cytosterile sources on *per se* performance for this trait.

Overall, the hybrids based on different cytosterile sources showed significant variations for days to 50 per cent flowering, head diameter, days to maturity, 100 seed weight, seed yield, oil content and oil yield. However, for *per se* performance for all these traits ARG-2-1-2 cytoplasm based hybrids were superior over MUT-2-8-3-2 cytoplasm based hybrids. The differences in these CMS analogues could probably be attributed to the favourable cytoplasmic effect/ nuclear interaction of ARG-2-1-2 cytosterile source over MUT-2-8-3-2. While there were no significant nuclear cytoplasm interaction for plant height, stem diameter, volume weight, hull content and percentage seed set indicating equal efficiency of both cytosterile sources in manifesting these traits. Previous studies of Rajanna *et al*. (2001); Patil *et al*. (2003); Tavoijanskiy *et al*. (2004) and Tyagi *et al*. (2020) have also confirmed the positive and negative influence of the cytosterile sources for various yield attributing traits in sunflower hybrids.

REFERENCES

KINMAN, M. L., 1970, New developments in USDA and state experiment station sunflower breeding programmes. In: Proc. *4th Inter., Sunflower Conf.,* Memphis, Tennessee, U.S.A., pp. : 181 - 183.

LECLERCQ, P., 1969, Line sterile cytoplasmique chezk tournesol. *Ann. Amelior Planta,* **12** : 99 - 106.

NEHRU, S. D., ESWARAPPA, G., RANGAIAH, S. AND KULKARNI, R. S., 2000, Studies on heterosis for seed yield and oil content to develop hybrids with high oil yield in sunflower (*Helianthus annuus* L.). *Mysore J. Agric. Sci.*, **34** (1) : 1 - 5.

PATIL, S. A., GAFOOR, A. AND RAVIKUMAR, R. L., 2003, Impact of cytoplasmic male sterile sources on seed

yield and yield components in sunflower (*Helianthus annuus* L.). *Helia.*, **26** (38) : 67 - 72.

RAJANNA, M. P., SEETHARAM, A., VIRUPAKSHAPPA, K. AND RAMESH, S., 2001, Heterosis in top-cross hybrids of diverse cytosterile sources of sunflower (*Helianthus annuus* l.) / heterosis en los hibridos top-cross del girasol creados de diversas fuentes citoesteriles / heterosisdans les hybrides top-cross de tournesol (*Helianthus annuus* L.) obtenus de diverses sources cytosteriles. *Helia*, **24** (34) : 25 - 34.

SEETHARAM, A., GIRIRAJ, K. AND KUSUMAKUMARI, P., 1980, Phenotypic stability of seed yield in sunflower hybrids. *Indian J. Genet.,* **40** : 102 - 104.

SEILER, G. J., LILI, L. Q., MAREK, L. F., 2017, Utilization of sunflower crop wild relatives for cultivated sunflower improvement. *Crop Sci.,* **57** : 1083 - 1101.

SHANKAR, V. G., GANESH, M., RANGANATHA, A. R. G., REDDY, D. L. AND SUMAN, A., 2006, Performance of elite inbreds with diverse cms sources in sunflower (*Helianthus annuus* L.). *Agric. Sci. Digest*, **26** (4) : 291 - 293.

SHARMA, M. AND SHADAKSHARI, Y. G., 2021, Economic heterosis in sunflower hybrids based on different cytoplasmic combinations for seed yield and its component traits. *Mysore J. Agric. Sci.*, **55** (2) : 35 - 44.

TAVOIJANSKIY, N. P., CHEPURNAYA, A. L., SCHERSTYUK, S. V. AND TIKHOMIROV, S. V., 2004, Development of sunflower sterile cms analogus to the base of different cytoplasmic backgrounds. *Helia*., **27** (40) : 251 - 256.

TYAGI, V. AND DHILLON, S. K., 2017, Effect of alien cytoplasm on combining ability for earliness and seed yield in sunflower under irrigation and drought stress. *Helia*, **40** (66).

TYAGI, V., DHILLON, S. K., KAUR, G. AND KAUSHIK, P., 2020, Heterotic effect of different cytoplasmic combinations in sunflower hybrids cultivated under diverse irrigation regimes. *Plants*, **9** (4) : 465.

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