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PERFORMANCE OF SEVEN NEW CYTOPLASMIC MALE-STERILE SUNFLOWER LINES FROM INDUCED MUTATION AND A NATIVE AMERICAN VARIETY

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SUMMARY

Six mutant cms HA 89 lines, *cms* PI 432513 from a native American variety, and the French *cms* PET1 in an HA 89 background were compared in replicated yield trials at Fargo, ND and Casselton, ND in 2003 and 2004. Data collected included lodging %, days to flower, days to maturity, plant height, head diameter, yield, test weight, seed moisture content, and oil concentration. Differences among the eight *cms* lines for lodging, days to maturity, head diameter, yield, and oil % were not significant. The other traits were significant among lines, but most of them were not significantly different from *cms* HA 89, with a maximum days to flower of 2 days later, plant height up to 9 cm taller, test weight from 2.8 kg/hl less to 1.2 kg/hl more, and 1000 seed weight from 2.6 g less to 6.0 g more. The six new *cms* lines are therefore considered agronomically equal to the French *cms* PET1. F_1 hybrids of these eight *cms* lines pollinated with oilseed restorer, RHA 274, and confectionery restorer, RHA 294, were also evaluated in separate yield trials. A similar interpretation for the parental *cms* lines can be made for the hybrids. The use of one oilseed restorer RHA 274, and one confectionery restorer RHA 294 contributed to the significant differences in days to flowering, plant height, test weight, 1000 seed weight, and oil %. However, the F_1 deviations involving the new *cms* lines from *cms* HA 89 are within the acceptable levels of most breeding programs. Based on our results, the seven new *cms* appear equal to, if not better than, the French *cms* PET1 cytoplasm for hybrid sunflower production. Since new restoration lines will not be required, the new *cms* lines could be quickly utilized by the sunflower industry.

Key words: **sunflower, *Helianthus annuus* L., cytoplasmic male sterility, fertility restoration**

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INTRODUCTION

World-wide hybrid sunflower production has been based on one cytoplasm, the French *cms* PET1 derived from *Helianthus petiolaris*, and a few restoration genes for nearly 30 years (Leclerq, 1969). The need for genetic diversity of both cytoplasmic and nuclear genes has been recognized, and new *cms* sources discovered (Serieys, 2002). However, there are no reports of utilization of these new *cms* sources for commercial hybrid production. This reluctance is assumably due to the lack of superior *cms* -restorer combinations, as well as the time-consuming process of converting both *cms* and restoration genes into inbred lines.

Jan and Rutger (1988) produced 22 cytoplasmic male-sterile mutants by treating maintainer line HA 89 with mitomycin-C and streptomycin. Male fertility of all mutant *cms* HA 89 lines and *cms* HA 89 was completely restored by RHA 266, RHA 274, RHA 280, and RHA 296. More recently, a native American Indian variety, PI 432513, was shown to possess male-sterile cytoplasm and a corresponding fertility restoration gene (Jan and Vick, 1997, 1998). *Cms* PI 432513 also was completely restored by six *H. petiolaris* restoration lines, RHA 265, RHA 266, RHA 274, RHA 294, RHA 296, and RHA 801. This uniform and complete fertility restoration of the 22 mutant *cms* HA 89 lines and *cms* PI 432513 suggested that Rf_1 was a factor in their restoration. Since the Rf_1 restoration gene is already in commercial restorer lines, hybrid breeding programs could focus primarily on *cms* line development.

The objectives of this study were to characterize six selected mutant *cms* HA 89 lines and *cms* PI 432513, and compare them with the French *cms* HA 89.

MATERIALS AND METHODS

Six mutant *cms* HA 89 lines, selected as sectorial *cms* on treated HA 89 plants and maintained by pollinating with HA 89, and *cms* PI 432513, with the pedigree of *cms* PI 432513/HA 89 *4 were used as new *cms* sources. Designations of these six mutant *cms* HA 89 lines are *cms* 45-1, *cms* 139-1, *cms* 491-1, *cms* 515-1, *cms* 555-1, and *cms* 3149. To avoid unequal competition between *cms* parental lines and the F_1 hybrids, two separate yield trials were established.

One trial included the six mutant *cms* HA 89 lines, *cms* PI 432513, and the French *cms* PET1 in an HA 89 background. The second trial included the F_1 progenies of these eight *cms* lines pollinated with oilseed restorer, RHA 274, and confectionery restorer, RHA 294. It was conducted in 2002 in the field at Fargo, ND.

A randomized complete block design with three replications was used for both trials. Each entry was planted in a 16-foot row, at Fargo and Casselton, North Dakota, in the summers of 2003 and 2004. The following data were collected: lodging %, days to flower, days to maturity, plant height, head diameter, yield, test weight, seed moisture content, and oil concentration. Data were processed by the analysis of variance (ANOVA).

Table 1: Performance of *cms* lines in HA 89 background averaged over two locations, Fargo and Casselton, North Dakota, in 2003 and 2004 field trials

cms line	Lodging (%)	Days to flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Yield (kg/ha)	Test weight (kg/hl)	1000 seed weight (g)	Oil (%)
cms 45-1	7	77	114	122.5	15.3	1502	32.8	54.3	45.77
cms 139-1	5	77	114	123.9	15.2	1584	30.5	50.7	45.78
cms 491-1	5	78	115	122.4	14.7	1527	32.2	53.1	45.47
cms 515-1	10	77	114	131.9	15.8	1559	31.1	49.6	44.82
cms 555-1	5	78	114	124.4	14.7	1332	29.1	54.0	45.22
cms 3149	6	79	114	125.8	16.1	1787	33.0	56.3	46.11
cms PI 432513	7	78	115	129.1	15.6	1762	33.1	58.2	44.97
cms HA 89	5	77	114	122.9	18.1	1462	31.9	52.2	46.32
Mean	6	77	114	125.4	15.7	1564	31.7	53.6	45.56
CV %	73	2	2	4.5	22.9	30	7.8	12.3	4.24
LSD 5%	NS	1	NS	4.6	NS	NS	2.0	5.4	NS
LSD 1%	NS	NS	NS	6.1	NS	NS	2.7	NS	NS

Table 2: Performance of F_1 hybrids averaged over two locations, Fargo and Casselton, North Dakota, in 2003 and 2004 field trials

Restorer/*cms* line	Lodging (%)	Days to flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	Yield (kg/ha)	Test weight (kg/hl)	1000 seed weight (g)	Oil (%)
RHA 274									
cms 45-1	6	74	116	174.6	18.1	2217	33.0	54.0	41.80
cms 139-1	7	73	117	177.4	17.2	1860	30.3	51.7	41.06
cms 491-1	6	73	115	179.3	17.5	1884	32.1	56.3	40.08
cms 515-1	5	73	116	175.5	18.4	2241	31.7	53.6	41.79
cms 555-1	9	73	115	183.7	18.1	2192	31.8	52.3	41.89
cms 3149	5	74	114	181.4	17.5	2176	33.9	55.8	41.75
cms PI 432513	6	73	115	182.8	17.5	2144	33.6	52.6	42.14
***cms* HA 89**	**4**	**73**	**114**	**184.1**	**18.3**	**2209**	**33.4**	**53.3**	**42.08**
RHA 274 Mean	**6**	**73**	**115**	**179.9**	**17.8**	**2115**	**32.5**	**53.7**	**41.57**
RHA 294									
cms 45-1	8	72	115	168.6	16.2	2095	32.5	76.2	36.71
cms 139-1	6	71	115	173.4	16.2	2168	31.3	77.7	37.15
cms 491-1	5	70	115	177.3	17.4	2128	31.2	83.8	36.98
cms 515-1	9	70	116	178.0	16.9	2265	31.7	77.1	38.23
cms 555-1	9	73	116	175.2	16.6	2071	31.4	79.0	37.86
cms 3149	6	71	114	178.3	17.3	2436	32.2	75.9	38.07
cms PI 432513	3	72	117	182.2	18.1	2273	30.2	81.7	36.33
***cms* HA 89**	**5**	**73**	**116**	**181.2**	**17.4**	**2306**	**32.1**	**80.7**	**36.95**
RHA 294 Mean	**6**	**72**	**116**	**176.8**	**17.0**	**2218**	**31.6**	**79.0**	**37.29**
Mean	**6**	**72**	**115**	**178.3**	**17.4**	**2167**	**32.0**	**66.4**	**39.43**
CV %	100	2	2	4.6	11.6	23	6.2	12.2	3.95
LSD 5%	NS	1	NS	6.6	NS	NS	1.6	6.5	1.26
LSD 1%	NS	2	NS	8.7	NS	NS	2.1	8.6	1.66

RESULTS AND DISCUSSION

Since the location × entry × year interaction was not significant for yield and other traits, the data were combined for the two locations and two years for analysis. No significant differences (5%) were detected among the eight *cms* lines for lodging, days to maturity, head diameter, yield, and oil % (Table 1). Days to flowering and 1000-seed weight were significant at 5%, and plant height and test weight were significant at 1%. However, in most cases difference between the seven lines and the French *cms* HA 89 were not significant, with a maximum days to flower of 2 days later, plant height up to 9 cm taller, test weight from 2.8 kg/hl less to 1.2 kg/hl more, and 1000 seed weight from 2.6 g less to 6.0 g more. Therefore, the six new *cms* lines appeared to be agronomically equal to the French *cms* PET1.

The performance of the hybrids was similar to that of the parental *cms* lines. Again, lodging %, days to maturity, head diameter, and yield were non-significant, and the other five characters were significant at 1% (Table 2). However, a large portion of this significance appeared to be due to the differences between the restorer lines. RHA 274 is an oilseeds restorer, with high oil %, which resulted in much higher oil % in its hybrids than that from crosses with the confectionery restorer RHA 294, which is low in oil content. The *cms* HA 89 crosses in respective groups differed up to three days in days to flowering, plant height by up to 12.6 cm, test weight by up to 3.1 kg/hl, 1000 seed weight by up to 4.8 g, and oil % by up to 2%. The F_1 deviations involving the new *cms* lines from *cms* HA 89 are within acceptable levels of most breeding programs.

Based on our results, the seven new *cms* sources appear to be equal, if not better than the French *cms* PET1 cytoplasm for hybrid sunflower production. The new *cms* lines are in *H. annuus* cytoplasm, but likely carry the same male sterility gene as that of the classical *H. petiolaris cms* used in commercial hybrid production. Since new restoration lines will not be required, the new *cms* lines can be quickly utilized by the sunflower industry. Seeds of the new *cms* lines were released to the public in 2005 and are available for breeding.

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CARACTERÍSTICAS DE SIETE LÍNEAS DE ESTERILIDAD CITOPLÁSMICA MASCULINA DE GIRASOL NUEVAS, ENGENDRADAS POR LA MUTACIÓN INDUCIDA Y UNA VARIEDAD AMERICANA NACIONAL

RESUMEN

Seis líneas mutadas originarias de cms HA 89, cms PI 432513 originaria de una variedad americana nacional y la línea francesa cms PET1 sobre la base de citoplasma HA 89, fueron comparadas en las pruebas de rendimiento, con repeticiones en Fargo, Dakota del Norte, y Kasellton, Dakota del Norte, a lo largo de los años 2003 y 2004. Los datos recolectados incluyen el porcentaje (%) de encame, número de días hasta la floración, número de días hasta la madurez, la altura de la planta, diámetro del capítulo, rendimiento, peso voluminoso, el contenido de humedad en el grano y el contenido de aceite. Las diferencias entre ocho líneas cms en el sentido de encame, el número de días hasta la madurez, diámetro del capítulo, rendimiento y el contenido de aceite, no fueron significantes. Las demás diferencias fueron significantes, pero la mayoría de esas diferencias no fueron significantes en relación con cms HA 89, con los valores máximos para el número de días hasta la floración de 2 días más tarde, para la altura de la planta de hasta 9 cm más alta, para el peso de volumen de 2.8 kg/hl menos hasta 1.2 kg/hl más y para el peso de 1000 granos de 2.6 g menos, hasta 6.0 g de más. Eso significa que las nuevas seis líneas cms pueden ser consideradas como agronómicamente iguales con la línea francesa PET1. Los híbridos F_1 de estas ocho líneas cms, polinizadas por el restaurador para el contenido de aceite, RHA 274, y restaurador del tipo de consumo, RHA 294, también fueron calificados en las separadas pruebas de rendimiento. Similares explicaciones, dadas para las líneas parentales cms pueden ser dadas para los híbridos, también. El uso de un restaurador para el contenido del aceite, RHA 274, y de un restaurador de tipo de consumo, RHA 294, ha contribuido a la presentación de las significativas diferencias en el número de días hasta la floración, altura de la planta, peso de volumen de 1000 granos y el porcentaje del aceite. Pero, la desviación en la generación F_1 de las nuevas líneas cms en relación hacia la línea cms HA 89, se encontraban dentro de los aceptables niveles para la mayoría de los programas de selección. Sobre la base de nuestros resultados, siete líneas nuevas cms parecen ser iguales, hasta mejores de la citoplasma francesa cms PET1 para la creación de los híbridos de girasol. Como las nuevas líneas restauradoras no van a ser necesarias, es posible incorporar en poco tiempo nuevas líneas cms en la producción de girasol.

PERFORMANCE DE SEPT NOUVELLES LIGNÉES DE TOURNESOL CYTOPLASMIQUE STÉRILES MÂLES CRÉÉES PAR MUTATION INDUITE ET D'UNE VARIÉTÉ DOMESTIQUE AMÉRICAINE

RÉSUMÉ

Six lignées cms mutantes HA 89, cms PI 432513 d'une variété américaine indigène et la lignée française cms PET1 sur une base de cytoplasme HA 89 ont été comparées dans des tests de rendement répétés à Fargo, au Dakota du Nord et à Casselton, Dakota du Nord en 2003 et en 2004. Les données recueillies comprennent le % de verse, le nombre de jours avant la floraison, le nombre de jours avant la maturation, la hauteur de la plante, le diamètre de la tête, le rendement, le poids spécifique, le taux d'humidité dans la graine et la concentration d'huile. Les différences entre les huit lignées cms pour la verse, le nombre de jours avant la maturité, le diamètre de la tête, le rendement, et le % d'huile n'étaient pas significatives. Les autres caractéristiques étaient significatives parmi les lignées, mais la plupart d'entre elles ne différaient pas de manière significative de la cms HA 89, avec un maximum de jours avant la floraison de deux jours plus tard, une hauteur de la plante de 9 cm plus élevée, un poids spécifique de 2,8 kg/hl de moins à 1,2kg/hl de plus et un poids de 1000 graines de 2,6 g de moins à 6,0 g de plus. De l'aspect agronomique, les six nouvelles lignées cms sont donc considérées égales à la ligne française cms PET1. Les hybrides F_1 de ces huit lignées cms pollinisées avec un restaurateur oléagineux, RHA 274 et un restaurateur de type comestible RHA 294 ont aussi été évaluées dans les contrôles de rendement distincts. Une interprétation semblable à celle des lignées parentales cms peut aussi être donnée pour les hybrides. L'utilisation d'un restaurateur oléagineux RHA 274 et un restaurateur de type comestible RHA 294 ont contribué à l'apparition de différences importantes pour ce qui est du nombre de jours avant la floraison, la hauteur de la plante, le poids spécifique, le poids de 1000 graines et le pourcentage d'huile. Cependant dans la génération F_1, les écarts des nouvelles lignées cms par rapport à la lignée cms HA 89 restent dans les niveaux acceptables de la plupart des programmes de sélection. D'après nos résultats, les sept nouvelles lignées cms semblent égales, sinon meilleures que le cytoplasme français cms PET1 pour la production d'hybrides de tournesol. Comme de nouvelles lignées de restauration ne seront pas nécessaires, il est possible d'inclure rapidement les nouvelles lignées cms dans la production du tournesol.