

**15<sup>e</sup> Conférence Internationale Tournesol**  
*15<sup>th</sup> International Sunflower Conference*



**12-15 juin 2000**  
*12-15 June 2000*

**Toulouse - France**  
*Toulouse - France*

**ACTES**  
***PROCEEDINGS***



**Tome II**

Session plénière / <i>Plenary session</i> : A - Economie / <i>Economics</i> . . . . .	TOME I
Session plénière / <i>Plenary session</i> : B - Technologie / <i>Technology</i> . . . . .	TOME I
Session plénière / <i>Plenary session</i> : C - Agronomie et Environnement / <i>Agronomy and Environment</i> . . . . .	TOME I
Session plénière / <i>Plenary session</i> : D - Génétique, Sélection et Biotechnologies / <i>Genetics, Breeding and Biotechnology</i> . . . . .	TOME I
Atelier posters / <i>Poster workshop</i> : A - Variation de la composition de l'huile / <i>Oil composition variation</i> . . . . .	TOME I
Atelier posters / <i>Poster workshop</i> : B - Nouveaux usages / <i>New uses</i> . . . . .	TOME I
Ateliers posters / <i>Poster workshops</i> : C - Conduites des cultures / <i>Crop management</i> . . . . .	TOME I
Ateliers posters / <i>Poster workshops</i> : D - Agro-physiologie / <i>Crop physiology</i> . . . . .	TOME I

**Ateliers posters / *Poster workshops* :**

**E - Productivité : composantes, aptitude à la combinaison, interaction génotype x environnement**  
***Productivity: components, combining ability, genotype x environment interaction***

EA70 - DIALLEL ANALYSIS IN SUNFLOWER ( <i>HELIANTHUS ANNUUS L.</i> ), GENETIC AND PHENOTYPIC CORRELATIONS FOR SOME AGRONOMICAL AND PHYSIOLOGICAL CHARACTERS . . . . .	E-1
<i>Franco Ceconi, Monica Gaetani, Raul Srebernich, Nestor Luciani</i>	
EA40 - COMBINING ABILITIES OF SUNFLOWER GENE POOLS ISSUED FROM CROSSES BETWEEN POPULATIONS AND INBRED LINES . . . . .	E-7
<i>Yves Griveau, Felicity Year, Michel Tersac, Patrick Vincourt</i>	
EA47 - HETEROTIC GROUPS IN SUNFLOWER . . . . .	E-13
<i>Antoine Mezzarobba, Jean-Louis Laffont, Jean-Louis D'Hautefeuille, Gilberto Sosa Dominguez, Herbert J. Schmidt, S. Thirthamallappa</i>	
EA36 - COMBINING ABILITY FOR OIL AND PROTEIN KERNEL CONTENTS OF SUNFLOWER INBREDS IN TWO DIFFERENT ENVIRONMENTS . . . . .	E-18
<i>Pilar Rojas, Dragan Skoric, José Maria Fernandez-Martinez</i>	
EA15 - GENERAL (GCA) AND SPECIFIC (SCA) COMBINING ABILITIES IN SUNFLOWER . . . . .	E-23
<i>Dragan Skoric, Sinisa Jovic, Igor Molnar</i>	
EA08 - LINE X TESTER ANALYSIS OF THE COMBINING ABILITY IN SUNFLOWER ( <i>H. annuus L.</i> ) . . . . .	E-30
<i>R. Marinkovic, D. Skoric, B. Dozet, D. Jovanovic</i>	
EA25 - RECIPROCAL CROSS AND CYTOPLASMIC EFFECTS ON AGRONOMIC TRAITS MEASURED ON ALLOPLASMIC HYBRIDS OF SUNFLOWER ( <i>H. annuus L.</i> ) . . . . .	E-36
<i>Hervé Serieys, Yves Griveau, François Kaan, André Bervillé</i>	
EA15 - INFLUENCE OF DIVERSE CYTOPLASMIC MALE STERILE SOURCES ON YIELD AND YIELD COMPONENTS IN SUNFLOWER . . . . .	E-42
<i>C.H. Abdul Gafoor, S.A. Patil, R. L. Ravikumar</i>	
EA05 - GENE EFFECT AND COMBINING ABILITY FOR PLANT STATURE AND HARVEST INDEX IN SUNFLOWER . . . . .	E-47
<i>Joksimovic J., Mihaljcevic M., Skoric D., Atlagic Jovanka</i>	
EA22 - GENOTYPE AND ENVIRONMENT EFFECTS ON LINEAR RATE OF INCREASE OF SUNFLOWER HARVEST INDEX AND ITS DURATION . . . . .	E-53
<i>Abelardo J. de la Vega, Antonio J. Hall</i>	
EA24 - GENOTYPE BY ENVIRONMENT INTERACTION AND INDIRECT SELECTION IN SUNFLOWER FOR ARGENTINA. I. MULTI-ATTRIBUTE TWO-MODE PATTERN ANALYSIS . . . . .	E-59
<i>Abelardo J. de la Vega, Scott C. Chapman, Antonio J. Hall</i>	
EA25 - GENOTYPE BY ENVIRONMENT INTERACTION AND INDIRECT SELECTION IN SUNFLOWER FOR ARGENTINA. II. THREE-MODE PRINCIPAL COMPONENT ANALYSIS . . . . .	E-65
<i>Abelardo J. de la Vega, Scott C. Chapman</i>	
EA26 - SPATIAL AND SEASONAL EFFECTS CONFOUNDING INTERPRETATION OF SUNFLOWER YIELDS IN ARGENTINA . . . . .	E-71
<i>Abelardo J. de la Vega, Scott C. Chapman</i>	
EA13 - GENOTYPE X ENVIRONMENT INTERACTION IN NEW SUNFLOWER ( <i>HELIANTHUS ANNUUS L.</i> ) HYBRIDS . . . . .	E-77
<i>Domenico Laureti, A. Del Gatto</i>	
EA28 - PHYSIOLOGICAL TRAITS ASSOCIATED WITH SUNFLOWER YIELD POTENTIAL: FUTURE OPORTUNIES . . . . .	E-82
<i>M. López Pereira, Y.O. Sadras, N. Trápani</i>	
EA30 - INTRASPECIFIC COMPETITION AND YIELD OF SUNFLOWER CULTIVARS RELEASED IN ARGENTINA BETWEEN 1963 AND 1998 . . . . .	E-88

Atelier posters/Poster workshop : F - Qualité des semences/Seed Quality

- EIN24 - STUDIES ON THE PERFORMANCE OF HYBRIDS DEVELOPED, THROUGH DIVERGENT POLLEN MIXTURES AND HYBRID MIXTURES/BLENDS IN SUNFLOWER  
I. Shanker goud, K. Gintoi
- ERU4 - THREE-WAY SUNFLOWER HYBRIDS: PROMISING DIRECTION OF INVESTIGATIONS  
Anatoly D. Bochkovoy, Victor P. Brazhnic, Nicolay I. Bochkarov, Valentina D. Savchenko
- EAR20 - FACTORES GENÉTICOS, AMBIENTALES Y CORRELACIONES ENTRE RENDIMIENTO Y CALIDAD DE GIRASOL  
Julio Gonzalez, Nora Mancuso, Carlos Oliva
- EAR36 - COMPARATIVE ANALYSIS OF GENETIC RELATIONSHIPS IN SUNFLOWER INBRED LINES, BASED ON ISOZYMIC, RAPD AND PEDIGREE DATA  
Guillermo G. Fizarro, Alicia D. Carrera, Mónica Foverene, Raul H. Rodriguez, Mercedes M. Echeverría, María T. Saladerry
- EBR4 - INBREEDING ASSESSMENT ON BRAZILIAN SUNFLOWER VARIETY EMBRAPA 122  
Marcelo Fernandes de Oliveira, Carlos Alberto Arrabal Arias, Vanja B. R. Castiglioni, Regina M.V.B.C. Leite
- EMEX1 - DROUGHT SUSCEPTIBILITY INDEX IN SUNFLOWER, A NEW APPROACH  
Daniel Gómez-Sánchez, Gian Paolo Vannozzi, Mario Baldini, Sattar Tahmasebi-Entezari, Carlos Espinosa-Zapata
- ERU2 - MORPHOLOGICAL FEATURES OF VEGETATIVE ORGANS IN SUNFLOWER LINES AND DIFFERENT TYPES OF GENETIC CONTROL OF DWARFNESS  
Vera Gavrilova, Elena Sokolova, Elena Yakovleva, Anton Yesaev
- EYU13 - INHERITANCE OF SEED SIZE IN SUNFLOWER  
Jocic Sinisa, Dragan Skoric, Igor Mohar
- EYU1 - INFLUENCE OF SOME INFLORESCENCE CHARACTERISTICS ON SEED YIELD OF SUNFLOWER INBRED LINES  
Jovanka Antagic, J. Joksimovic, V. Miklic, D. Skoric
- EAR9 - DISTRIBUCION DE LA PRODUCCION Y VIABILIDAD DEL POLEN EN EL CAPTULO DE GIRASOL (Helianthus annuus L.)  
Valeria E. Caramutti, Luis F. Hernandez, Marta A. Caccovari, Ofelia A. Naab
- EROU1 - SELECTION OF SUNFLOWER RESTORER INBRED LINES ACCORDING TO THE POLLEN AMOUNT  
Elena Andrei, Carmen Doina Iltreanu
- ELT9 - CHIMERA INDUCTION IN SUNFLOWER (HELIANTHUS ANNUUS L.). ANALYSIS OF SECTOR PATTERNS FOR DIFFERENT GENETIC MARKERS  
Franco Cecconi, Mauro Durante, Raul Srebernich, Nestor Luciani
- EFT5 - CHARACTERISATION OF GRAIN YIELD PERFORMANCES OF FOUR SUNFLOWER VARIETIES USING HETEROSEDASTIC MIXED FACTORIAL REGRESSION  
Y. Foutcau
- FAR42 - EFECTO DEL TAMAÑO DE SEMILLA Y DE LA REMOCION DE LA CASCARA CON Y SIN PILDORADO DE LA PEPITA SOBRE EL NUMERO DE PLANTAS LOGRADAS EN UN HIBRIDO DE GIRASOL CONIFERO  
Sergio Uhart, Mariano Fugone, Guillermo Pozzi, Ramon Correa, Claudio Simonella
- EBR6 - INFLUENCE OF SUNFLOWERSEED GRADING ON GERMINATION AND VIGOUR  
Jocely Andruccetti Maeda, Maria Regina Gonçalves Ungaro
- FIN28 - INFLUENCE OF SEED VIGOUR ON CROP GROWTH AND YIELD OF BSH-1 HYBRID SUNFLOWER UNDER NORMAL AND COMPENSATED SEED RATES  
V.P. Kalappa, K. Somasekhara, P. Balakrishna
- FIN26 - STUDIES ON STANDARDISATION OF SIEVE SIZE FOR PROCESSING OF KRSH-1 HYBRID SUNFLOWER SEEDS  
K. Somasekhara, K. Krishnegowda, Chikkadevaiah, B.C. Channakeshava, V.P. Kalappa, K. Seenappa
- ESP4 - ESTIMACION DEL VIGOR DE AQUENIOS DE GIRASOL POR MEDIO DEL IRUTRON-2000  
Jose Miguel Silveira, Jose Maria Duran, Luis Manuel Navas Gracia
- FIN29 - PREDICTION OF STORAGE POTENTIAL OF SEED LOTS OF SUNFLOWER STORED AT DIFFERENT LOCATIONS IN KARNATAKA STATE  
V.P. Kalappa, K.R.R. Prasanna, K. Somasekhara, P.J. Devraj
- FIN31 - INFLUENCE OF SEED TREATMENT AND SEED PACKAGING CONTAINERS ON SEED QUALITY AND STABILITY OF HYBRID SUNFLOWER  
B.C. Channakeshava, Chikkadevaiah, K. Somasekhara
- FF59 - DEVELOPMENT OF A TEST TO DIAGNOSE THE PRESENCE OF SUNFLOWER DOWNY MILDW (PLASMOPARA HALSTEDII) IN SEED SAMPLES  
Veronique Savy-Lesage, Cipri Meliata, Jeanne Tourville, Paul Nicolas, Denis Tourville de Labrouhe, Patricia Koeckel-Drevet
- EF8 - DEVELOPMENT OF AN ELISA TEST TO DETECT PLASMOPARA HALSTEDII ANTIGENS IN SEED  
Sandrine Bouterige, Raymond Robert, Agnes Marot-Leblond, Jean-Marcel Sener, Valerie Molinero-Demilly

## Atelier posters/Poster workshop : G - Traitement des semences/Seed treatment

- E-1 G.F14a - MISE AU POINT D'UNE MÉTHODE DE CONTAMINATION ARTIFICIELLE EN VUE DE L'EXPÉRIMENTATION DE FONGICIDES SUR PLASMOPARA HALSTEDII . . . . . G-1  
*Marc Delos, Nathalie Eychenne, Isabelle Birba, Duprat C., Miallier D., Denis Tourvieille de Labouhe D*
- E-1 G.F14b - ETUDE DE L'EFFICACITÉ PRATIQUE DE DIVERS FONGICIDES SUR PLASMOPARA HALSTEDII AU MOYEN D'UNE MÉTHODE DE CONTAMINATION ARTIFICIELLE . . . . . G-7  
*Marc Delos, Nathalie Eychenne, Michaud I., Taverna S., Jacquot A., Péres A.*
- E-1 G.SP7 - TOLERANCE TO METALAXYL IN SPANISH ISOLATES OF PLASMOPARA HALSTEDII . . . . . G-11  
*M. Leire Molinero Ruiz, Juan Domínguez, José M. Melero Vara, Thomas J. Gulya*
- E-1 G.HSA41 - METALAXYL RESISTANCE IN SUNFLOWER DOWNY MILDEW AND CONTROL THROUGH GENETICS AND ALTERNATIVE FUNGICIDES . . . . . G-16  
*T. J. Gulya*
- E-1 G.AR35 - EFECTO SINERGICO DEL INSECTICIDA IMIDACLOPRID SOBRE ALGUNAS VARIABLES MORFO-FISIOLOGICAS DEL GIRASOL . . . . . G-22  
*P.J. Paoloni, L.F. Hernández, C.N. Pellegrini, R. Bottini*
- E-1 G.MU17 - EFFICACY OF INSECTICIDES FOR THE CONTROL OF SOME HARMFUL ORGANISMS IN SUNFLOWER VIA SEED TREATMENT . . . . . G-27  
*Radosav Sekuljac, Stevan Masirevic, Tatjana Keresi*

## Atelier posters/Poster workshop : H - Entomologie/Entomology

- H-17 - FLORA COMPETIDORA EN LA POLINIZACIÓN DE GIRASOL PARA PRODUCCIÓN DE SEMILLA HÍBRIDA, POR APIS MELLIFERA L., EN EL SUR DE LA PCIA. DE BUENOS AIRES, ARGENTINA . . . . . H-1  
*Liliana Gallez, Ana Andrada, Alda Valle, Pablo Paoloni y Luis Hernández*
- H-13 - THE NECTAR PRODUCTION OF SUNFLOWER HYBRIDS AND THE FREQUENCY OF BEE VISITS AT TWO LOCATIONS IN HUNGARY . . . . . H-7  
*Gábor Bujáki, Zoltán Horváth*
- H-19 - LES EFFETS DE PESTICIDES SUR L'APPRENTISSAGE OLFACTIF CHEZ L'ABEILLE DOMESTIQUE APIS MELLIFERA L. . . . . H-11  
*Axel Decourtye, Bernard Roger, Jean-François Odoux, Minh-Hà Pham-Delègue, Sophie Cluzeau*
- H-14 - METHOD FOR DETERMINATION OF TOTAL IMIDACLOPRID RESIDUES IN SUNFLOWER NECTAR . . . . . H-18  
*Alain Quinsac, Mohammed Krouti, André Merrien*
- H-15 - BIOLOGY AND PEST MANAGEMENT STRATEGIES FOR THE SUNFLOWER BEETLE IN CULTIVATED SUNFLOWER IN NORTH AMERICA . . . . . H-22  
*Laurence D. Charlet*
- H-16 - EVALUACION Y MANEJO DE ORUGAS CORTADORAS (Lepidoptera: Noctuidae) EN CULTIVO DE GIRASOL EN ARGENTINA . . . . . H-28  
*Jorge R. Aragón*
- H-17 - PLAGAS PRINCIPALES DEL GIRASOL EN LA PROVINCIA DE CORDOBA, ARGENTINA . . . . . H-34  
*Jorge R. Aragón*
- H-18 - DAMAGE BY THE NEOTROPICAL BROWN STINK BUG, *Euschistus heros* (F.) (HEMIPTERA: PENTATOMIDAE) TO SUNFLOWER IN BRAZIL . . . . . H-41  
*Andrea B. Malaguido, Jovenil J. Silva, Osvaldo V. Vieira, Antônio R. Panizzi*
- H-19 - BT-MEDIATED INSECT RESISTANCE IN SUNFLOWER (*Helianthus annuus*, L.) . . . . . H-46  
*G. Pozzi, M. Lopez, G. Cole, G. Sosa-Dominguez, D. Bidney, C. Scelonge, L. Wang, Lu, Guihua, J. Müller-Cohn, G. Bradfisch*

## Atelier posters/Poster workshop : I - Epidémiologie, description des maladies/Epidemiology, description of diseases

- I-1 - OCCURRENCE OF SCLEROTINIA SCLEROTIUM ROT IN SUNFLOWER FIELDS SOWED AFTER HARVESTING OF SUMMER CROPS, IN THE STATE OF PARANA, BRAZIL . . . . . I-1  
*Regina M.V.B.C. Leite, Marcelo Fernandes de Oliveira, Vania B. R. Castiglioni*
- I-2 - MOLECULAR AND PHENOTYPIC CHARACTERISATION OF FRENCH ISOLATES OF DIAPORTHE HELIANTHI / PHOMOPSIS HELIANTHI MUNT.-CVET . . . . . I-5  
*Anne Vigié, Véronique Says-Lesage, Pascal Walser, Jeanne Tourvieille, Patricia Drevet, Paul Nicolas, Félicity Year, Denis Tourvieille de Labrouhe*
- I-3 - LE PHÉNOMÈNE "PIEDS SECS" DU TOURNESOL : IMPLICATION DU PHOMA ET ÉTUDE DU MÉCANISME DE LA CONTAMINATION . . . . . I-11  
*André Pérès, Blandine Boisson*

1.F21 - LE SYNDROME "PIEDS SECS" DU TOURNE SOL : ETUDE DES CAUSES ET APPROCHE DE LA NUISIBILITE  
André Pères, Blandine Poisson, Geoffroy Drolon

1.F22 - LE PHOMA DU TOURNE SOL (PHOMA MACDONALDII FORME IMPARFAITE DE LEPTOSPHAERIA LINDQUISTII ) :  
ETUDE DES PÉRITHÈCES ET DES PYCNIDES DANS LE PROCESSUS DE LA CONTAMINATION  
André Pères, Virginie Le Souffre

1.F5 - ETUDE DE L'ACTIVITE PHYTOTOXIQUE DE PHOMA MACDONALDII, AGENT PATHOGENE RESPONSABLE DE LA MALADIE DES TACHES NOIRES  
Anne Chailou, Corinne Lafite, Claudia Pelage, Ali Roustaee, Gregory Déchamp-Guillemme, Gérard Barrault

1.F11 - ETUDE DE L'ÉPIDÉMIOLOGIE DE LEPTOSPHAERIA LINDQUISTII, AGENT DE LA MALADIE DES TACHES NOIRES DUTOURNE SOL EN FRANCE  
Marc Delos, Jacques Moineard, Nathalie Eychenne

1.USAZ - RUST RESISTANCE IN WILD HELIANTHUS ANNUUS AND VARIATION BY GEOGRAPHIC ORIGIN  
Tom Gulya, Gary Kong, Mary Brothers

1.F12 - ETUDE DES FACTEURS EXPLIQUANT LES FLUCTUATIONS DES ATTAQUES DE PLASMOPARA HALSTEDII EN FRANCE  
Marc Delos, Nathalie Eychenne, Isabelle Birba, Christine Fabry

1.F18 - BILAN DE DIX ANNEES DE SURVEILLANCE DU MILDIOU DU TOURNE SOL EN FRANCE  
Serge Lafon, Marc Delos, Isabelle Kaulic, Denis Tourville de Labrouhe

1.H2 - POPULATION STUDIES ON PLASMOPARA HALSTEDII: HOST SPECIFICITY AND FUNGICIDE TOLERANCE  
Ferenc Viranyi, Ilona Walcz

1.F57 - NEW NOMENCLATURE OF RACES OF PLASMOPARA HALSTEDII (SUNFLOWER DOWNY MILDW)  
Denis Tourville de Labrouhe, Thomas J. Gulya, Stevan Mastrevic, Annette Fenaud, Khalid Y. Rashid, Ferenc Viranyi

1.F60 - MOLECULAR VARIABILITY OF PLASMOPARA HALSTEDII  
Jeanne Tourville, Joël Millon, Patricia Koedel-Drevet, Denis Tourville de Labrouhe, Thomas J. Gulya

1.F61 - SUNFLOWER DOWNY MILDW: SYMPTOMATOLOGY, EPIDEMIOLOGY AND ECONOMIC RISKS OF SECONDARY INFECTION  
Cipri Meliata, Felicity Year, Denis Tourville de Labrouhe

1.US44 - METALAXYL RESISTANCE IN SUNFLOWER DOWNY MILDW AND CONTROL THROUGH GENETICS AND ALTERNATIVE FUNGICIDES  
T. J. Gulya

1.US46 - CHARACTERIZATION AND HOST RANGE OF SUNFLOWER MOSAIC POTYVIRUS  
T.J. Gulya, P. H. Berger, P.J. Shiel, T.R. Freeman, T.S. Isakeit

1.AR21 - ANALYSIS OF ATTACK OF SCLEROTINIA HEAD ROT OF SUNFLOWER IN ARGENTINA (Sclerotinia sclerotiorum (Lib.) de Bary)  
Norma I. Huguet, Patricia Heiland

**Atelier posters/Poster workshop : 1 - Résistance verticale/Vertical resistance**

J.F64 - THE INHERITANCE OF RESISTANCE TO OROBANCHE CUMANA IN SUNFLOWER  
Geneviève Gagne, Patricia Koedel-Drevet, Bruno Grezes-Besset, Pepa Shindrova, Peter Ivanov, Philippe Blanchard, Yun-Hai Lu, Paul Nicolas, Felicity Year

J.F83 - MÉCANISMES DE RÉSISTANCE DU TOURNE SOL À OROBANCHE CUMANA WALLR  
Labrousse Pascal, Arnaud Marie-Claire, Veronesi Christophe, Serreys Hervé, Berville André, Thalouarn Patrick

JUS1 - RESISTANCE OF SUNFLOWER (Helianthus) PERENNIAL SPECIES, INTERSPECIFIC AMPHILOIDS, AND BACKCROSS PROGENY  
TO BROOMRAPE (O. CUMANA WALLR.) RACES  
C.C. Jan, Juan A. Ruso, Juan Muñoz-Ruz, Jose M. Fernandez-Martinez

J.U3 - SUNFLOWER BREEDING FOR RESISTANCE TO BROOMRAPE (OROBANCHE CERNUA LOEFL./OROBANCHE CUMANA WALLR.)  
Branislav Dozet, Dragan Skoric, Dejan Jovanovic

J.US5 - RESISTANCE TO WHITE RUST (ALBUGO TRAGOPOGONIS) AND EVIDENCE OF MULTIPLE GENES  
T. J. Gulya, P. S. van Wyk, A. Vilson

J.F54 - GENETICAL ANALYSES OF THE SUNFLOWER DOWNY MILDW RESISTANCE GENE PLS  
Felicity Year, Jacqueline Phillipon, Sylvie Roche, Pascal Wieser, Denis Tourville de Labrouhe, Said Mouzeyar, Paul Nicolas

J.F63 - CLONING AND ANALYSIS OF RESISTANCE GENE ANALOGS IN SUNFLOWER  
Mouzeyar S., Bouzidi M.F., Bodouzi S., Cambon F., Tourville de Labrouhe D., Year F., Nicolas P.

J.GE1 - MOLECULAR MARKERS AS A TOOL IN BREEDING FOR RESISTANCE AGAINST SUNFLOWER DOWNY MILDW  
Lutz Brahm, Volker Hahn, Thomas Kocher, Wolfgang Friedl

1007	HIGH OLEIC ACID CONTENT IN SUNFLOWER GENOTYPES IN RELATION WITH RESISTANCE TO DISEASES . . . . .	J-49
	<i>Maria Păcureanu-Joita, Alexandru Viorel Vrânceanu, Danil Stanciu and Steluta Raranciuc</i>	
1008	IDENTIFICATION OF PROTEASOME (PROSOME) ASSOCIATED ENDONUCLEASE ACTIVITY IN PLANTS . . . . .	J-57
	<i>Lionel Ballut, Franck Petit, Saïd Mouzeyar, Hans-Peter Schmid, Paul Nicolas, Saloua Badaoui</i>	

**Oral posters / Poster workshop : K - Résistance horizontale / Horizontal resistance**

1009	SUNFLOWER WHITE ROT INCIDENCE: COMBINING ABILITY OF INBRED LINES AND RELATIVE PERFORMANCE OF HYBRIDS IN TWO ENVIRONMENTS . . . . .	K-1
	<i>Marcela Godoy, Fernando Castaño, José Ré, Raúl Rodríguez, Alberto Escande</i>	
1010	SCLEROTINIA DU BOURGEON TERMINAL DU TOURNESOL : AMÉLIORATION DE MÉTHODES D'ÉVALUATION DU COMPORTEMENT VARIÉTAL EN SERRE . . . . .	K-7
	<i>André Pérès</i>	
1011	SCLEROTINIA SUR COLLET DE TOURNESOL : MÉTHODOLOGIE DE L'ÉVALUATION DU COMPORTEMENT VARIÉTAL EN SERRE . . . . .	K-13
	<i>André Pérès, Denise Poinsignon, Bruno Grèzes-Beset</i>	
1012	RESISTANCE TO SCLEROTINIA HEAD ROT IN SUNFLOWER AFTER ARTIFICIAL INFECTION WITH INOCULATED MILLET SEED . . . . .	K-19
	<i>Volker Hahn</i>	
1013	COMPARISON BETWEEN ARTIFICIAL INOCULATION AND CULTURE FILTRATE OF SCLEROTINIA SCLEROTIUM LIB. DE BARY TREATMENTS ON NINE SUNFLOWER GENOTYPES . . . . .	K-23
	<i>Sattar Tahmasebi-Enferadi, Maurizio Turi, Mario Baldini, GianPaolo Vannozzi</i>	
1014	STUDIES ABOUT THE INFLUENCE OF SCLEROTINIA SCLEROTIUM FILTRATES ON SOME QUANTITATIVE AND QUALITATIVE TRAITS IN ROMANIAN SUNFLOWER GENOTYPES IN VITRO AND IN VIVO TESTED . . . . .	K-29
	<i>Florentina Răducanu, Al. V. Vrânceanu, Ioana Hagima, Elena Petcu</i>	
1015	ACCUMULATION OF SOLUBLE PHENOLIC COMPOUNDS IN SUNFLOWER CAPITULA CORRELATES WITH TOLERANCE TO SCLEROTINIA SCLEROTIUM . . . . .	K-35
	<i>E. Prats-Pérez, M.E. Bazzalo, A. León, J.V. Jarrín-Novo</i>	
1016	PEDIGREE SELECTION FOR SUNFLOWER CAPITULUM RESISTANCE TO SCLEROTINIA SCLEROTIUM . . . . .	K-42
	<i>Felicity Vear, Frédéric Serre, Pascal Walser, Henri Bony, Georges Joubert, Denis Tourvieille de Labrouhe</i>	
1017	ANALYSES OF QTL ASSOCIATED WITH RESISTANCE TO SCLEROTINIA SCLEROTIUM AND DIAPORTHE HELIANTHI IN SUNFLOWER (HELIANTHUS ANNUUS L.) USING MOLECULAR MARKERS . . . . .	K-48
	<i>Pierre-François Bert, Isabelle Jouan, Frédéric Serre, Florence Cambon, Denis Tourvieille de Labrouhe, Paul Nicolas, Felicity Vear</i>	
1018	THE RELATIONS BETWEEN THE RECESSIVE GENE FOR APICAL BRANCHING (B1) AND SOME DISEASE RESISTANCE AND AGRONOMIC CHARACTERS . . . . .	K-54
	<i>Isabelle Jouan, Pierre-François Bert, Florence Cambon, Annie Perrault, Denis Tourvieille de Labrouhe, Paul Nicolas, Felicity Vear</i>	
1019	SCLEROTINIA HEAD ROT RESISTANCE CONFERRED BY WHEAT OXALATE OXIDASE GENE IN TRANSGENIC SUNFLOWER . . . . .	K-60
	<i>Maria Eugenia Bazzalo, Ian Bridges, Teresa Galella, Martín Grondona, Alberto León, Alan Scott, Dennis Bidney, Glenn Cole, Jean-Louis D'Hautefeuille, Guihua Lu, Mark Mandl, Chris Scelonge, John Soper, Gilberto Sosa-Dominguez, Lijuan Wang</i>	
1020	TRANSGENIC SCLEROTINIA RESISTANCE IN SUNFLOWER ( <i>Helianthus annuus</i> , L.) . . . . .	K-66
	<i>Chris Scelonge, Lijuan Wang, Dennis Bidney, Guihua Lu, Craig Hastings, Glenn Cole, Mark Mandl, Jean-Louis D'Hautefeuille, Gilberto Sosa-Dominguez, Sean Coughlan,</i>	
1021	CONSTITUTIVE PROMOTERS AND SCLEROTINIA DISEASE RESISTANCE IN SUNFLOWER . . . . .	K-72
	<i>Guihua Lu, Dennis Bidney, Zhongmeng Bao, Xu Hu, Ju Wang, Tim Vortherms, Chris Scelonge, Lijuan Wang, Aihua Shao, Wes Bruce, Jon Duvick</i>	
1022	THE USE OF NATURAL INFECTIONS UNDER CONTROLLED CONDITIONS AND OF ARTIFICIAL INFECTIONS TO ESTIMATE PHOMOPSIS RESISTANCE OF SUNFLOWER HYBRIDS: CONCLUSIONS AFTER TEN YEARS OF TRIALS . . . . .	K-76
	<i>Anne Viguié, Frédéric Serre, Pascal Walser, Felicity Vear, Denis Tourvieille de Labrouhe</i>	
1023	EVALUATION OF SUNFLOWER GERMLASM FOR RESISTANCE TO PHOMOPSIS STEM CANKER . . . . .	K-84
	<i>Masirevic Stevan</i>	
1024	ANALYSE GENETIQUE DE LA RESISTANCE AU PHOMOPSIS (DIAPORTHE HELIANTHI MUNT.-CVET. ET AL.) CHEZ LE TOURNESOL CULTIVE . . . . .	K-90
	<i>Kamel Langar, Yves Griveau, Hervé Serieys, André Bervillé</i>	
1025	COMPORTEMENT DE GENOTYPES DE TOURNESOL (HELIANTHUS ANNUUS L.) A DES INFECTIONS ARTIFICIELLES SUR FEUILLES AVEC CINQ ISOLATS FRANÇAIS DE PHOMOPSIS (DIAPORTHE HELIANTHI MUNT.-CVET. ET AL.) . . . . .	K-96
	<i>Kamel Langar, Yves Griveau, Laurent Ziercher, Hervé Serieys, André Bervillé</i>	
1026	STABILITY OF SUNFLOWER RESISTANCE TO VERTICILLIUM WILT . . . . .	K-102

**Atelier posters/Poster workshop : L - Biologie cellulaire, Biotechnologie/Cellular biology, Biotechnology**

- K.BR9 - ALTERNARIA RESEARCH DEVELOPMENT IN SÃO PAULO STATE, BRAZIL  
*Maria Regina Gonçalves Ungaro*
- K.IN22 - POLLEN SELECTION AND PROGENY EVALUATION FOR ALTERNARIA LEAF BLIGHT RESISTANCE IN SUNFLOWER (HELIANTHUS ANNUUS L.)  
*R.L. Ravikumar*

LIT15 - MORPHOGENETIC COMPETENCE IN THE GENUS HELIANTHUS: INCREASED TOTIPOTENCY IN PLANTS PREVIOUSLY REGENERATED IN TISSUE CULTURE AND CHARACTERIZATION OF AN EPIPHYLLIC VARIANT  
*Claudio Pugliesi, Roberto Bianchi, Giuliano Cionini, Marco Fambirini*

LF2 - AGAROSE-INDUCED EMBRYOID FORMATION : ACTIN MICROFILAMENTS AS DETERMINANTS OF THE MEMBRANE-MATRIX ADHESION SIGNAL TRANSDUCTION  
*Petitprez Michel, Henri Barthou, Brière Christian, Jouveau Alain, Albert Gilbert*

LF4 - DO LIM PROTEINS REGULATE THE CYTOSKELETON DYNAMICS IN SUNFLOWER PROTOPLASTS?  
*Ann-claire Borel, Christian Brière, Henri Barthou, Michel Petitprez, André Steinmetz, Gilbert Albert*

LF67 - IN VIVO LABELING OF SUNFLOWER (HELIANTHUS ANNUUS L.) EMBRYONIC TISSUES BY FLUORESCENT PHENYLALANINE HIGHLIGHTS THE EMBRYO PROTOPLAST ROLE IN ION EXCHANGES VIA ION CHANNELS  
*Xu Xuhua, Christian Brière, Nathalie Vallée, Gilbert Albert, André Souvère*

LF10 - CONTRÔLE GÉNÉTIQUE DE LA RÉSISTANCE DU TOURNE SOL A PHOMOPSIS HELIANTHI  
*Laurence Deglène, Gilbert Albert, Philippe Lesigne, Denis Tourville de Labrouhe, Ahmad Sarahi*

LGER7 - SINGLE PROTOPLAST MICROINJECTION AS A PROCEDURE USED TO DELIVER SMALL AND LARGE MOLECULES INTO THE CELL  
*P.C. Binsfeld, C. Cerboncini, H. Schnabl*

LGER8 - CHARACTERIZATION OF INTERSPECIFIC ASYMMETRIC SOMATIC HYBRIDS AND THEIR PROGENY IN THE GENUS HELIANTHUS  
*P.C. Binsfeld, C. Cerboncini, H. Schnabl*

L.VU19 - RAPID ANALYSIS OF SUNFLOWER SOMATIC HYBRID CALLI  
*Dragana Vasic, Gilbert Albert, Andre Berville, Dragana Skoric*

L.BU7 - INDUCED PARTHENOGENESIS IN SUNFLOWER (HELIANTHUS ANNUUS L.): EFFECT OF GAMMA-IRRADIATION DOSES  
*Miglena Todorova, Peter Ivanov*

L.VU18 - ANOTHER CULTURE OF SUNFLOWER CULTIVARS  
*Dragana Vasic, Dragana Skoric, Simsa Jotic*

M.B1 - RECHERCHE DE SYNTHE ENTRE LES GÉNOMES D'HELIANTHUS ANNUUS, ARABIDOPSIS THALIANA, ET BETA VULGARIS PAR EMPLOI D'ESTS PROVENANT DE CES ESPÈCES  
*Isabelle Dominguez, Abdellah Barakat, Stephen R. Barne, Simon T. Berry*

M.USA12 - SIMPLE SEQUENCE REPEAT LENGTH POLYMORPHISMS AMONG ELITE INBRED LINES OF SUNFLOWER: ANALYSIS OF PUBLIC SECTOR CARTISOL III MARKERS  
*Ju-Kyung Yu, Jodie Mangor, Steven J. Knapp, Lucy Thompson, Keith Edwards*

M.USA17 - GENETIC DIVERSITY AMONG 23 USDA INBRED LINES USING cDNA PROBES  
*Brady A. Vick, C.C. Jan, Jerry F. Miller, A.L. Kahler*

M.CH2 - USE OF RAPD MARKERS TO SCREEN HYBRIDS OF OILSEED SUNFLOWER  
*Liu Gongshu, Mo Jiesheng, Liu Jie, Sun Baogqi*

M.AR26 - USE OF RFLP MARKERS FOR GENETIC LINKAGE ANALYSIS OF DAYS TO FLOWERING IN SUNFLOWER (HELIANTHUS ANNUUS L.)  
*Alberto Leon, Fernando Hector Andrade, Michael Lee*

M.F3 - CONTRÔLE GÉNÉTIQUE DE L'ORGANOGENÈSE IN VITRO CHEZ LE TOURNE SOL (HELIANTHUS ANNUUS L.) ET IDENTIFICATIONS DES RÉGIONS CHROMOSOMIQUES IMPLIQUÉES  
*Ericka Flores Bertios, Ahmad Sarahi, Gilbert Albert, Georges Berton, André Berville, Laurent Genzbitzel*

M.RU1 - GENETIC STUDIES ON SUNFLOWER SEED STORAGE PROTEINS  
*Irina Anisimova, Alexander Konarev, Saida Turkay, Vera Gavrilova, Peter Shewry*

M-1016	IDENTIFICATION OF RAPD MARKERS LINKED TO DROUGHT TOLERANCE BY BULKED SEGREGANT ANALYSIS . . . . .	M-38
	<i>Dejana M. Pankovic, Zvonimir O. Sakac, Marijana I. Plesnicar, Dragan M. Skoric</i>	
M-1017	A MOBILE GENETIC UNIT ASSOCIATED WITH DISEASE RESISTANCE IN SUNFLOWER . . . . .	M-44
	<i>Wendy Lawson, Ian Godwin, Gary Kong, Joseph Kochman</i>	

**Workshop posters/Poster workshop :**

**N - Perspectives du développement du tournesol dans différents pays  
Future development of the sunflower around the world**

N-1	POTENTIALITY OF OIL SUNFLOWER IN CHINA . . . . .	N-1
	<i>Liu Gongshe, Liu Jie, Li Fangfang</i>	
N-6	MANIFESTACIONES TERRITORIALES DE LA EXPANSION DEL CULTIVO DE GIRASOL EN ARGENTINA . . . . .	N-6
	<i>Liliana Iriarte, Susana Silvia Brieva</i>	
N-12	THE ROLE AND POSITION OF SUNFLOWER IN UK AGRICULTURE . . . . .	N-12
	<i>Sarah K. Cook, Alastair McCartney, Brian Fletcher, Peter D Hutley-Bull, Ian Barrie, David Harris</i>	
N-18	TECHNOLOGY TRANSFER FOR IMPROVING SUNFLOWER PRODUCTION IN BRAZIL . . . . .	N-18
	<i>Oswaldo V. Vieira, Lineu A. Domit, Marcelo F. Oliveira</i>	
N-22	SUNFLOWER HYBRIDS ADAPTED TO THE FINNISH GROWING CONDITIONS . . . . .	N-22
	<i>Tarja A. Niemelä, Unto E. Tulisalo</i>	
N-27	IDENTIFICATION OF SUNFLOWER HYBRIDS APPROPRIATE FOR DRYLAND AGRICULTURE . . . . .	N-27
	<i>A. Manjunath, P. Ramanagowda, S.D. Nehru, Panduranga, B.R. Hegde</i>	
N-31	SELECTION OF SUNFLOWER HYBRIDS FOR BOSNA I HERZEGOVINA (BIH) . . . . .	N-31
	<i>Jovan Kondic</i>	

**Workshop posters/Poster workshop : O - Ressources génétiques/Genetic resources**

O-1	PRELIMINARY EVIDENCE FOR THE CYTOPLASMIC CONTROL OF TRANSPIRATION EFFICIENCY IN SUNFLOWER . . . . .	O-1
	<i>Christopher J. Lambrides, Scott C. Chapman, Bodapati P. Naidu, Ray Shorter</i>	
O-7	PRODUCTION, STUDY AND UTILIZATION OF SUNFLOWER INTERSPECIFIC HYBRIDS . . . . .	O-7
	<i>Vera Gavrilova, Galina Nizova, Tatyana Tolstaya, Nickolay Tavalzhansky, Elena Akhtulova, Emiliya Slyusar</i>	
O-13	RFLP APPLIED TO INTERSPECIFIC PROGENIES REVEALED CROSS FAILURE AND TRUE HYBRIDISATION BETWEEN SUNFLOWER AND HELIANTHUS PERENNIAL SPECIES . . . . .	O-13
	<i>Nathalie Faure, Hervé Serieys, Yves Griveau, François Kaan, André Bervillé</i>	
O-19	INHERITANCE AND FATE OF TRANSLOCATIONS IN H. ARGOPHYLLUS T.&G. X H. ANNUUS PROGENIES . . . . .	O-19
	<i>N. Madjidian, A. Bervillé</i>	
O-25	EVALUATION OF AN INTERSPECIFIC SUNFLOWER POPULATION ISSUED FROM THE PERENNIAL SPECIES H. OCCIDENTALIS SSP. PLANTAGINEUS FOR RESISTANCE TO DIAPORTE HELIANTHI AND SCLEROTINIA SCLEROTIUM IN RELATION WITH PHENOTYPIC AND MOLECULAR TRAITS . . . . .	O-25
	<i>Hervé Serieys, Abderrahmane Tagmount, François Kaan, Yves Griveau, Michel Tersac, Thierry André, Hugues Grave, Xavier Pinochet, André Bervillé</i>	
O-31	BREEDING FOR ALTERNARIA RESISTANCE IN SUNFLOWER: APPROACHES FOR INTROGRESSION FROM WILD SUNFLOWERS . . . . .	O-31
	<i>A.J. Prabakaran, M. Sujatha</i>	
O-37	DEVELOPMENT OF HERBICIDE RESISTANT GERMPASM IN SUNFLOWER . . . . .	O-37
	<i>Jerry F. Miller, Kassim Al-Khatib</i>	
O-42	IMIDAZOLINONE-RESISTANT SUNFLOWER ( <i>Helianthus annuus</i> ): INHERITANCE OF RESISTANCE AND RESPONSE TOWARDS SELECTED SULFONYLUREA HERBICIDES . . . . .	O-42
	<i>Goran Malidza, Dragan Skoric, Sinisa Jocić</i>	
O-48	HISTOCHEMICAL AND CHROMATOGRAPHIC CHARACTERIZATION OF FUNGAL DISEASE RELATED DEFENSE STRUCTURES IN PERENNIAL HELIANTHUS SPECIES . . . . .	O-48
	<i>C. Carboncini, G. Beine, H. Peisker, P.C. Binsfeld, H. Schnabl</i>	



## INHERITANCE OF SEED SIZE IN SUNFLOWER

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### SUMMARY

There are several ways to increase yield per unit area. One of the most commonly used ways is to increase seed size and seed number per head while maintaining or raising the number of plants per unit area. Breeding for seed size may prove to be of great importance in increasing sunflower yields.

In order to study the mode of inheritance, components of genetic variance and combining ability for seed length, width and thickness (seed size), half diallel crosses of six divergent sunflowers inbred lines were made. The results have shown that there existed significant differences between the parent lines and their progenies regarding the mean values of the three traits.

In the inheritance of seed length, width and thickness, the additive gene effect proved to be of great importance since the value of the additive component (D) was considerably higher than that of the dominant component ( $H_1$ ,  $H_2$ ). The average degree of dominance indicates the presence of partial dominance in the inheritance of the three investigated traits in the progenies. The inbred line cms-13 had the highest positive values of general combining ability for all examined characters. The best specific combinations for all three investigated traits were R-15 x cms-19 and cms-77 x R-18.

## INTRODUCTION

Sunflower seed yield is the product of three basic components: number of heads per unit area, number of seeds per unit area and the mass of single seed (*Merrien, 1992*). The commonly used method of yield increase involves the increases in seed number and size per head while simultaneously maintaining or increasing the number of plants per unit area. The ratio kernel vs. husk too plays an important role in increasing oil yield per unit area (*Škorić, 1996*). *Evans* (1981) points out that the key for increased genetic yield potential is an increased ability of the sink to compete with other organs for assimilates. The competitive ability depends on the relative size of organs, their relative distance from the source of assimilates and the relative orientation and volume of their vascular bonds. An increased sink should be put in balance with stem height and leaf architecture. The increase in the sink, i.e., the increase in the number and mass of grains per spike, ear, head, etc., is a way for further improvement (*Borojević, 1992*). The botanical name for the sink in the sunflower is 'achene', while the commonly used term is 'seed'. It is comprised of pericarp, meristem and the germ with cotyledons. For the purposes of oil industry, the seed is divided into husk and kernel with germ.

*Dakov* (1969) maintained that the best way to increase oil yield per unit area is to increase kernel yield per unit area, i.e., to increase the number of kernel's cells capable of oil accumulation. High oil and low oil varieties differ more in kernel yield than in oil-accumulating capacity of the kernel. According to *Škorić* (1974) seed yield and oil content in seed determine oil yield forming, while *Pathak* (1974) found a significant positive correlation between seed yield per plant and the mass of 1,000 seeds (kernels). Conversely, *Putt* (1943) reported negative correlations between kernel content and seed size, which occurred in nine out of eleven cases. It led him to believe that the selection for lines with small seeds may produce breeding material with high kernel content. However, according to *Pustovoit* (1966), the pioneer breeder of high oil sunflower varieties, seed quality, i.e., seed size is an important resource for increased yield. The selection for seed size, i.e., for increased mass of 1,000 seeds, may be an important asset in sunflower yield increase. Studies have shown that the increase in the mass of 1,000 seed by a single gram increases the yield by 40 kg/ha (*Morozov, 1970*). *Sun Liangning* (1996) believes that the selection for elongated seed and the mass of 1,000 seeds over 70 g leads to yield increase.

When breeding for seed size, it is well advised to keep in mind the findings of *Dakov* (1982) on high negative correlation between seed size and the number of seeds per plant - if an increased number of seeds are formed, each seed has a smaller portion of available resources. The regression between seed number and seed size has the form of a hyperbola, while the correlation between the two traits is negative. The additive component of genetic variance governed the inheritance of seed length and width, the non-additive component governed the inheritance of seed thickness (*Marinković and Škorić, 1987*). *Stojanova and Porisova* (1982) found a direct positive effect of seed length and thickness on seed yield level, and a direct negative effect of seed width on seed yield level. Seed length was negatively correlated while seed thickness was positively correlated with oil content in seed (*Marinković and Škorić, 1988*). Absence of negative correlation between oil content and seed size was reported by *Zali and Samadi, (1978)*.

The objectives of this study were to establish the components of genetic variability for seed size (length, width and thickness) in sunflower and to examine the effects of general and specific combining abilities for these traits employing the diallel cross method.

## MATERIALS AND METHODS

Six sunflower inbred lines (restorer lines R-15, R-17, R-18, and maintainer lines cms-13, cms-19 and cms-77) were selected for analysis of components of genetic variance, general and specific combining abilities for seed length, width and thickness. The lines were divergent regarding the investigated traits.

In the first year of the experiment (1997), the lines were diallelly crossed for  $n(n-1)/2$  combinations, excluded reciprocals. The plants used as the female component were emasculated by hand, in early morning, before anthers open up. In 1998, the parents and the  $F_1$  generation were sown in a comparative trial established after the system of random blocks in three replicates. The comparative trial was sown in the optimum period, on a well-prepared chernozem soil, at the Rimski Šančevi experiment field of the Institute of Field and Vegetable Crops. Intensive cultivation practices were applied in the trial. The harvesting was done by hand.

Thirty plants (ten plants per replicate) were taken from the comparative trial for analyses. The sampled plants were taken from inner rows. Seed length, width and thickness were measured with a micrometer caliper. Data were processed by MSTATC (Michigan State University, version 1986), Program for Quantitative Genetic Analysis IDC-AGRO/CuSof (Institute of Field and Vegetable Crops) and SYSTAT, Version 5.02, 1991, Systat Inc. The analysis of combining ability was done after *Griffing* (1956), method 2, model I, the analysis of components of genetic variance after the method of *Jinks* (1954), *Hayman* (1954) and *Mather and Jinks* (1971).

## RESULTS AND DISCUSSION

The studied sunflower inbred lines differed significantly regarding seed length, width and thickness. Among the parent lines, the line R-15 had the smallest seed length, the line cms-13 the largest, 8.57 mm and 15.08 mm, respectively (Table 1). In the  $F_1$  generation, the largest average seed length was found in the combination cms-77 x cms-13, the smallest in R-15 x R-18, 14.22 mm and 8.98 mm, respectively. The parents' mean values for seed width varied from 3.51 mm in the inbred line R-18 to 8.71 mm in cms-13. The largest average seed width in the  $F_1$  generation was found in the hybrid combination cms-13 x R-17, the lowest in R-15 x R-18, 8.02 mm and 3.86 mm, respectively. The inbred line cms-13 had the highest mean value for seed thickness, the line R-18 the lowest, 4.71 mm and 2.41 mm, respectively. In the  $F_1$  generation, the highest and the lowest mean values were found in the combinations cms-13 x R-17 and R-15 x R-18, respectively. Seed length, width and thickness were largest in the combinations of lines with highest mean values for these traits and vice versa.

The analysis of variance showed highly significant differences in GCA and SCA for all three traits (Table 2). Since GCA is considered as an indicator of additive genetic variance, and SCA an indicator of non-additive variance, i.e., of dominance and epistasis, it may be concluded that seed length, width and thickness are controlled by both additive and non-additive gene action. However, the additive effects are much higher, as indicated by the high values of the ratios GCA/SCA for all traits. The analysis of general combining ability showed that the parents with highest mean values were at the same time best general combiners for the studied traits. This is also an indication of the additive mode of inheritance of these traits. The inbred cms-13 had the highest positive values of general combining ability, which were highly significant for all three traits (Table 3). Also, the lines cms-77 and cms-19 were good general combiners for seed length, while the lines cms-19 and R-17 were good general combiners for seed width and thickness. The combinations R-15 x cms-19 and cms-77 x R-18 had highly significant values of specific combining ability for the studied traits (Table 3). These combinations confirm once again that high SCA values are frequently obtained by crossing

parents with high GCA (in our case cms-19 and cms-77) to parents with poor GCA R-15, R-18).

Table 4 shows the values of and ratios among the components of genetic variance for seed length, width and thickness. The values of the additive component (D) being much higher than the values of the dominant component ( $H_1$ ,  $H_2$ ), it may be concluded that, when all combinations are taken into account, the additive gene effect is more important than the non-additive effect in the inheritance of the studied traits. These results are not in full agreement with the results of *Marinković and Škorić* (1987) who found the additive gene action to control the inheritance of seed length and width and the non-additive gene action to control the inheritance of seed thickness. The F value was positive in all cases, indicating the predominance of dominant over the recessive genes. This was further confirmed by the frequencies of dominant (u) and recessive alleles (v), the former being higher for all three traits. The dominant and recessive alleles were not evenly distributed among the parents since the values of  $H_2/4H_1$  were not equal to 0.25. The ratio  $Kd/Kr$  was larger than unity in all parents and for all traits, indicating the prevalence of dominant over the recessive alleles. As the average degree of dominance [ $(H_1/D)^{1/2}$ ] was invariably lower than unity, it may be concluded that, when all combinations are taken into account, seed length, width and thickness are inherited partially dominantly.

### CONCLUSION

The obtained results indicate that the studied lines differed significantly in the investigated traits. Significant differences in mean values were also found among parent lines and hybrids. Both additive and non-additive component of genetic variance were important for the inheritance of seed length, width and thickness. However, the ratio between the components indicates that the additive gene action prevails over the non-additive one. This is in full agreement with the results of the analysis of components of genetic variance, which indicated the preponderance of the additive component over the dominant component. The line cms-13 was the best general combiner for the investigated traits; the combinations R-15 x cms-19 and cms-77 x R-18 were the best specific combiners. When all combinations are taken into account, seed length, width and thickness are inherited partially dominantly.

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Table 1 - Mean seed length (SL), seed width (SW) and seed thickness (ST) of parents (diagonal) and F<sub>1</sub> generation (upper right) for a 6 x 6 diallel cross in sunflower (values are totaled over three replications)

Parent	Character	Parent					
		R-15	cms-77	cms-19	cms-13	R-17	R-18
R-15	SL	8.57	10.96	10.82	11.86	10.09	8.98
	SW	3.58	5.70	6.35	5.79	5.23	3.86
	ST	2.52	3.79	3.92	3.90	3.43	2.53
cms-77	SL		12.42	12.29	14.22	12.11	11.51
	SW		5.18	5.69	7.19	6.65	5.57
	ST		2.92	3.48	3.58	4.23	3.42
cms-19	SL			11.42	13.80	11.62	10.48
	SW			5.68	7.51	6.52	5.97
	ST			3.45	3.96	3.87	3.44
cms-13	SL				15.08	13.20	12.12
	SW				8.71	8.02	6.12
	ST				4.71	4.42	3.58
R-17	SL					10.24	9.54
	SW					5.81	4.48
	ST					3.62	2.28
R-18	SL						9.19
	SW						3.51
	ST						2.14

Table 2 - Analysis of variance of combining ability for seed length (SL), seed width (SW) and seed thickness (ST)

Source of variance	Character	Degrees of freedom	Mean of squares	Fe	F 0.05	F 0.01
GCA	SL	5	11.52	589.11	3.51	2.45
SCA		15	0.13	6.61	2.55	1.94
E		40	0.02			
GCA/SCA			88.61			
GCA	SW	5	6.04	503.05	3.51	2.45
SCA		15	0.41	34.03	2.55	1.94
E		40	0.01			
GCA/SCA			14.73			
GCA	ST	5	1.19	165.71	3.51	2.45
SCA		15	0.15	21.27	2.55	1.94
E		40	0.01			

Table 3 - Combining ability for seed length (SL), seed width (SW) and seed thickness (ST)

Parent and hybrid	SL	Rank	SW	Rank	ST	Rank
GCA values						
R-15	-1.303	6	-0.866	5	-0.259	5
cms-77	0.697	2	0.013	4	-0.011	4
Cms-19	0.240	3	0.296	2	0.111	3
Cms-13	1.885	1	1.376	1	0.556	1
R-17	-0.404	4	0.185	3	0.173	2
R-18	-1.115	5	-1.004	6	-0.570	6
SE (gi)	0.045		0.035		0.027	
LSD 5%	0.141		0.111		0.086	
1%	0.180		0.148		0.115	
SCA values						
R-15 x cms-77	0.096	10	0.694	4	0.536	3
R-15 x cms-19	0.413	2	1.060	1	0.538	2
R-15 x cms-13	-0.185	14	-0.583	15	0.076	7
R-15 x R-17	0.331	4	0.049	8	-0.005	10
R-15 x R-18	-0.068	11	-0.133	12	-0.168	12
cms-77 x cms-19	-0.120	13	-0.478	13	-0.144	11
cms-77 x cms-13	0.172	9	-0.058	10	-0.219	13
cms-77 x R-17	0.348	3	0.590	6	0.540	1
cms-77 x R-18	0.452	1	0.695	3	0.473	4
cms-19 x cms-13	0.205	8	-0.028	9	-0.234	14
cms-19 x R-17	0.318	5	0.180	7	0.065	9
cms-19 x R-18	0.238	7	0.811	2	0.368	5
cms-13 x R-17	0.257	6	0.593	5	0.160	6
cms-13 x R-18	-0.119	12	-0.115	11	0.067	8
R-17 x R-18	-0.410	15	-0.567	14	-0.251	15
SE (ij)	0.102		0.080		0.062	
LSD 5%	0.346		0.271		0.210	
LSD 1%	0.463		0.363		0.281	

Table 4 - Components of genetic variability in sunflower

Component	Character		
	Seed length	Seed width	Seed thickness
D	7.59	3.61	0.83
H <sub>1</sub>	0.51	1.50	0.55
H <sub>2</sub>	0.40	1.33	0.46
F	0.65	0.92	0.38
E	0.01	0.01	0.01
H <sub>2</sub> /4H <sub>1</sub>	0.23	0.22	0.70
U	0.65	0.67	0.30
V	0.35	0.33	0.21
(H <sub>1</sub> /D) <sup>1/2</sup>	0.26	0.64	0.82
Kd/Kr	1.39	1.49	1.79