19TH INTERNATIONAL SUNFLOWER CONFERENCE

TRAKYA ÜNİVERSİTESİ 1982

ISC 2016

29 MAY – 3 JUNE, 2016

EDIRNE, TURKEY

ISC 2016

PROCEEEDINGS
OF
19TH INTERNATIONAL SUNFLOWER CONFERENCE

29 MAY – 3 JUNE, 2016

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19TH INTERNATIONAL SUNFLOWER CONFERENCE

29 MAY – 3 JUNE, 2016,

EDIRNE, TURKEY

In

Trakya University Balkan Congress Center,

Edirne, Turkey

Organized by

Trakya University

and

International Sunflower Association

WELCOME from the CHAIR

You are welcome to our conference that will be jointly organized by Trakya University and International Sunflower Association. The aim of our conference is to present scientific subjects of a broad interest to the sunflower community, by providing an opportunity to present their work as oral or poster presentations that can be of great value for global sunflower production and trade. Our goal is to bring three communities, namely science, research, and private investment together in a friendly environment of Edirne, Turkey in order to share their interests and ideas and to benefit from the interaction with each other.

Our Conference held with record participation with over 600 people working on sunflower as researchers, scientists from seed companies, from oil industry and machinery coming from all part of the World. We have 300 papers which is a record number and almost doubles the previous meetings.

Due to many inquiries about combining our activities with oil industries in ISC 2016, International Sunflower Oil Quality Symposium are organized as one day as a side event during the conference. Sunflower farmers and growers will join also to our conference, so it will be also interesting as an initial attempt to bring together triangle dimensions as scientist, growers and industry in our conference.

Conference activities;

Plenary sessions with oral and poster presentations are on 30th, 31st of May and 1st of June 2016. Besides, the field day and the Sightseeing tours are on June 2nd – 3rd June 2016.

Agriculture is an important sector feeding all humankind, but it needs new developments and technologies to supply enough food for increasing world population year by year. Turkey is one of the most important contries on sunflower production and trade and an example to the leading agricultural economies in the world. Therefore, we hope that this conference will help to solve the problems encountered in the Sunflower community with establishing good network collaborations, joint projects and better relationships among countries with sharing our knowledge and experience together. We wish success to this meeting and hope a great scientific achievement together with your contributions.

Edirne is not only a very nice, lovely and historical city at the edge of Europe, but located just at the heart of Balkan region and history endowed with monuments reminding imperial past. We are much pleased to host you all in Edirne and in Turkey.

We would like to thank you to join this conference and we would like to give also special thanks our sponsors and collaborators for giving us big supports to organize this event.

We wish you nice stay in Edirne for truly rewarding days.

Assoc Prof Dr Yalcin KAYA

Head of Organizing Committee
President of International Sunflower Association

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Dr. Janet KNODEL	North Dakota State Univ.	USA	Sunflower Insects

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SESSIONS	SPEAKER
Breeding	Dr Branislav DOZET (Hungary)
Molecular Breeding	Dr. Lili QI (USA)
Agronomy and Seed Production	Dr Philippe DEBAEKE (France)
Genetic Resources	Dr Laura MAREK (USA)
Disease & Pest resistance and Management	Prof Dr Steven MASIREVIC (Serbia)
Orobanche Resistance and Management	Dr Maria JOITA-PACUREANU (Romania)
Abiotic Stress Tolerance and Management	Dr Nicolas LANGLADE (France)
Herbicide Resistance and Management	Dr Goran MALIDZA (Serbia)
Confectionery	Dr Nada HLADNI (Serbia)

INVITED SPEAKERS of INTERNATIONAL SUNFLOWER OIL QUALITY SYMPOSIUM

NAME	INSTITUTION	COUNTRY
Prof Dr Nurhan T. DUNFORD	Oklahoma State Univ.	USA
Fabrice THURON	Fat & Associes,	FRANCE
Dr Leanordo VELASCO	CSIC, Cordoba,	SPAIN

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19TH INTERNATIONAL SUNFLOWER CONFERENCE
29 MAY – 3 JUNE, 2016
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CONFERENCE PROGRAM

GENERAL SESSION

SUNDAY, MAY 29th, 2016	
14 00 - 20 30	**Registration at Hotels and Balkan Congress Center**
MONDAY, MAY 30th, 2016	
08 30 - 09 30	Registration at Balkan Congress Center
09 30 - 10 30	Opening Ceremony Balkan Synphony Orchestra Slide Show: Sunflower from Soil to Table:Our Yellow Bride in the fields Giving Appreciation Certficates to our Sponsors
10 30 – 11 00	Coffee break
11 00 - 12 30	**OPENING SESSION:** Session Chair: ***PROF DR MARIA DUCA*** – Rector of University of Moldova Academy of Science
11 00 – 11 40	***Invited Speaker*** **Prof Dr. Dragan Skoric "HISTORY OF SUNFLOWER BREEDING IN THE WORLD"**
11 40 – 12 20	***Invited Speaker*** **Dr. Lili Qİ "MOLECULAR MAPPING OF THE DISEASE RESISTANCE GENES AND ITS IMPACT ON SUNFLOWER BREEDING"**
12 20 – 12 30	DISCUSSION
12 30 – 13 30	**LUNCH ((Courtesy of Nidera Semillas)**

	GENETIC AND BREEDING	BIOTIC AND ABIOTIC STRESS TOLERANCE	CROP PRODUCTION AND MANAGEMENT	MOLECULAR GENETICS
	(Main Meeting Room)	**(2nd Floor Senate Meeting Room)**	**(2nd Floor Left Meeting Room)**	**(2nd Floor Right Meeting Room)**
30.05.2016 MONDAY		**30.05.2016 MONDAY**	**30.05.2016 MONDAY**	**30.05.2016 MONDAY**
13^{30} -15^{30}	***1st Session Chair: CARLOS FEOLI***	***1st Session Chair: DR MARIA JOITA- PACUREANU***	***1stSession Chair:DR VALENTINA ENCHEVA***	***1stSession Chair: DR RENATE HORN***
13^{30} -13^{50}	***Invited Speaker*** **DR BRANISLAV DOZET** Contemporary Challenges in Sunflower Breeding	The genetics and evolution of solar tracking – B. BLACKMAN, S. HARMER	Use of polymer hydrogel in soil moisture conservation for sunflower cultivation in rainfed situations of Northern Karnataka, India: A case study – U. SHANWAD, B. CHITTAPUR, SHANKERGOUD I, B. DESAI, GOVİNDAPPA MR., V. KULKARNI	The cultivated sunflower pan genome provides insights on the wild sources of introgressions and their role in breeding – S. HUBNER, E. ZIGLER, J.R. MANDEL, D. SWANEVELDER, P. VINCOURT, N. LANGLADE, J. M. BURKE, L. H. RIESEBERG
13^{50} -14^{10}		Impact of exogenously applied glycine betaine on physiological attributes of sunflower under drought stress- NOSHIN I., NADIA Z., N. BATOOL, Q. BANO	Determination of the yield and yield components performance of some sunflowers (*Helianthus annuus* L.) under rainfed conditions – I. DEMIR	Principal Component Analysis for Carbon Isotope Discrimination-Related Traits in Recombinant Inbred Lines of Sunflower – A. L. ADIREDJO, T. LAMAZE, P. GRIEU
14^{10} -14^{30}	Genetic analysis of seed yield related traits under optimum and limited irrigation in sunflower – M. GHAFFARI	Rapid invitro screening of sunflower genotypes for moisture stress tolerance using PEG 6000 - SHANKERGOUD I., SHESHAIAH K. C.	Appropriate nitrogen (N) and phosphorus (P) fertilizer regime for sunflower (Helianthus annuus L.) in the humid tropics – E. AKPOJOTOR, V. OLOWE	Molecular Studies of Sunflower Responses to Abiotic Stresses – I. TINDAS, R. I. AYTEKIN, S. ÇALIŞKAN
14^{30} -14^{50}	Breeding for sunflower hybrids adapted to climate change: the SUNRISE collaborative and multi-disciplinary Project - LUBRANO-LAVADERA A.S., M. COQUE, MUNOS S., DEBAEKE P., MANGIN B., GOUZY J., KEPHALİACOS C., PIQUEMAL J., PINOCHET X.,	Exploring drought tolerance related traits in *Helianthus argophyllus*, *Helianthus annuus* and their hybrids – M. MUBASHAR HUSSAIN, M. KAUSAR, M. KHAN, P. MONNEVEUX	Interactive Effects of Different Intra-Row spacing and Nitrogen Levels on Yield and Yield Compenents of confectionery sunflower (*Helianthus annuus* L.) genotype (Alaca) Under Ankara conditions – S. DAY, O. KOLSARICI	Comparative assessment of androgenic response in sunflower (*Helianthus annus*) – N. AKGUL, E. ÇABUK ŞAHIN, Y. AYDIN, A. ALTINKUT UNCUOGLU, G. EVCI, A GÜREL

	LANGLADE N.			
14^{50}-15^{00}	Discussion	Discussion	Discussion	Discussion
15^{00}-15^{30}	Coffee break	Coffee break	Coffee break	Coffee break
15^{30}-17^{00}	***2nd Session: Chair: DR VLADIMIR MIKLIC***	***2nd Session: Chair: DR FELICITY VEAR***	***2nd Session Chair: PROF DR GIAN PAOLO VANNOZZI***	***2nd Session Chair: DR PHILIPPE DEBAEKE***
15^{30}-15^{50}	Assessment of sunflower germplasm selected for cold tolerance under autumn planting conditions in Morocco - HOUMANAT K., MAZOUZ H., EL FECHTALI M., NABLOUSSI A.	***Invited Speaker*** **PROF DR STEVAN MAŠIREVIĆ** Sunflower diseases research progress and management	Global change adaptation: what future for sunflower crops and products? A foresight study for oilseed chains at 2030 horizon – E. PILORGE, A. M. TREMBLAY, F. MUEL	Molecular and genetic aspects of sunflower defensive response to downy mildew - T. ȘESTACOVA, A.PORT, M. DUCA
15^{50}-16^{10}	Perspective and challenges to develop high yielding, disease resistant and oil quality sunflower hybrids in India - R.K.SHEORAN		Bioactivity and Phytochemical Evaluation of Sunflower (*Helianthus annuus* L.) Leaf Extract – Y. BIBI, A. QAYYUM, S. NISA	Recent Molecular Studies on Downy Mildew Disease – A. K. TURKMEN, S. CALISKAN
16^{10}-16^{30}	Stability performance of new introduced sunflower hybrids for seed yield and its components under Sudan conditions – A. A. M. ABDALLA	Control of Verticillium dahliae causing sunflower wilt using Brassica green manures - DESSERRE D., MESTRIES E., DECHAMP-GUILLAUME G., SEASSAU C.	Effects of Different Organomineral and Inorganic Compound Fertilizers on Seed Yield and Some Yield Components of Sunflower (*H. annuus* L.) – S. SUZER, E. CULHACI	Molecular Studies involved in sunflower responses in drought stres - I. ALTINDAS, E. AKSOY, S. CALISKAN
16^{30}16 ^{45}	Discussion	Discussion	Discussion	Discussion
16^{45}-18 ^{00}	***Poster Session***	***Poster Session***	***Poster Session***	***Poster Session***
19 ^{30} -	**Dinner Party (Courtesy of Syngenta)**	**Dinner Party (Courtesy of Syngenta)**	**Dinner Party (Courtesy of Syngenta)**	**Dinner Party (Courtesy of Syngenta)**

	31.05.2016 TUESDAY	31.05.2016 TUESDAY	31.05.2016 TUESDAY	31.05.2016 TUESDAY
09^{30} -10^{10}	***3RD Session Chair: DR OLIVIER COTTET***	***3RD Session Chair: PROF DR* STEVAN MASIREVIC**	***3RD Session Chair: DR AMELIA BERTERO DE ROMANO***	***3RD Session Chair: DR DRAGANA MILADINOVIC***
09^{30} -09^{50}	Collection of wild *Helianthus anomalus* and *deserticola* sunflower from the desert southwest USA – G. SEILER, L. MAREK	Isolation and identification of pathogen of Sunflower *Fusarium* Wilt - JING G. YUAN YUAN Z., GUİ Z., JİAN Z., KAİ W., JUN Z.	***Invited Speaker*** **DR PHILIPPE DEBAEKE** Sunflower and climate change in Europe: crop vulnerability, adaptation, and mitigation potential	Proteomic response of sunflower to drought stres – M. GHAFFARI, M. TOORCHI, M. VALIZADEH
09^{50} -10^{10}	The b1 locus that controls apical shoot branching in *H. annuus* exhibits a molecular diversity linked to the breeding history of hybrids - DURIEZ P., BONIFACE, M. C., POUILLY N., VAUTRIN S., MAYJ., RODDE N., BERGES H., CARRERE S., GOUZY J., P. VINCOURT, J. PIQUEMAL, S. MUNOS	Distribution of *Plasmopara halstedii* pathotypes in Hungary – R. BÁN, A. KOVÁCS, G. BAGLYAS, M. PERCZEL, G. TUROCZI, K. KOROSI		Identification of HaDELLA, HaGID1 as well as HaSLEEPY and HaSNEEZY genes involved in gibberellin signaling in sunflower - R. EWALD, N. GEHM, L. POPIOLKOWSKI, A. ANTELMANN, R. HORN
10^{10} -10^{30}	Phenotypic and genotypic characterization of 400 new sunflower pre-bred lines – G. BAUTE, W. ANYANGA, E. ALBRECHT, L. H. RIESEBERG	Exploitation of the knowledge on oomycete effectors to drive the discovery of durable disease resistance to downy mildew in sunflower – Y. PECRIX, L. BUENDIA, Q. GASCUEL, C. PENOUILH-SUZETTE, L. GODIARD	Chemical Broomrape (*Orobanche cumana*) control in Clearfield® sunflower with different Imazamox containing herbicide formulations – M. PFENNING, M. VALTIN, S. SASCHA, J. BESSAI	Characterization of sunflower inbred lines with high oleic acid content by DNA markers – B. B. BILGEN
10^{30} -10^{50}	Developing well adapted hybrids in Europe by using a G*E approach - GAUTIER F., HELOISE H., MILAGROS G., SAUVAIRE D.	Response to sunflower (*Helianthus annuus* L.) plant at early growth stage to cadmium toxicity – Y. CIKILI, H. SAMET, N. C. ATIKMEN	Pulsar® Plus and Eurolightning® Plus - herbicides for enhanced weed control in Clearfield® Plus sunflower – J. BESSAİ, SCHLÄFER S., PFENNING M., MORAN D., CARTIN J.	Evaluation of WRKY and MYB transcription factors in some downy mildew infected sunflower lines; microarray data analysis – E. FILIZ, I. I. ÖZYİĞİT, R. VATANSEVER

10^{50} -11^{00}	Discussion	Discussion	Discussion	Discussion
11^{00} -11^{20}	Coffee break	Coffee break	Coffee break	Coffee break
11^{20}-12^{30}	***4th Session: Chair: DR SINISA JOCIC***	***4th Session Chair: DR MICHAEL FOLEY***	***4th Session Chair: DR SUJATHA MULPURI***	***4th Session Chair: PROF DR RISHI BEHL***
11^{20}-11^{40}	Correlation studies between SSR marker based genetic distance and heterosis in sunflower (*Helianthus annuus* L.) – V. KULKARNI, SHANKERGOUD I., SUPRIYA S.M, SURESHA P.G.	PCR combined with GFP tagged *Verticillium dahliae* confirmed the seeds transmission of Sunflower *Verticillium* Wilt - YUAN YUAN Z., GUI Z., JIAN Z., JUN Z.	Relationships between Germination and Vigor Tests with Field Emergence of Sunflower in Iran – H. SADEGHI, S. SHEIDAEI	***Invited Speaker*** **DR STEPHANE MUNOS** De novo sequencing of the *Helianthus annuus* and *Orobanche cumana* genomes
11^{40}-12^{00}	Optimization of Agrobacterium-mediated gene transfer systems in Turkish sunflower (*Helianthus annuus* L.) varieties – I. I. ÖZYİĞİT, S. KARADENIZ, H. TOMBULOGLU, E. FILIZ	Stability of the level of partial resistance to white rot in sunflower – M. ANABELLA DINON, F. CASTAÑO, S. SAN MARTINO, J. LÚQUEZ, F. QUIROZ	Pest Monitoring and Handling System Based on 4G Mobile System – C. ATLIG	
12^{00}-12^{20}	Inclusion of dominance effect in genomic selection model to improve predictive ability for sunflower hybrid performance – F. BONNAFOUS, N. LANGLADE, B. MANGIN	Genetic divergence among sunflower inbred lines and their convergent improvement for yield, quality and disease resistance- R. RANI - R. K. SHEORAN – S. CHANDER – R. K. BEHL	New seed treatment solutions for *Plasmospora* Resistance Management in Sunflower – F. BRANDL	Comparison of cytoplasmic male sterility based on PET1 and PET2 cytoplasm in sunflower (*Helianthus annuus* L.) - HORN R., REDDEMANN A., DRUMEVA M
12^{20}-12^{30}	Discussion	Discussion	Discussion	Discussion
13^{30}-13^{30}	**Lunch (Courtesy of Edirne Farmer Union)**	**Lunch (Courtesy of Edirne Farmer Union)**	**Lunch (Courtesy of Edirne Farmer Union)**	**Lunch(Courtesy of Edirne Farmer Union)**
13^{30}-15^{30}	***5th Session Chair: DR THIERRY ANDRE***	***5th Session Chair: DR ROBERT NEMETH***	***5th Session Chair: PROF DR BENJAMIN BLACKMAN***	***5th Session Chair: PROF DR DEJANA PANKOVIC***
13^{30}-13^{50}	***Invited Speaker*** **DR MARIA JOITA-PACUREANU** Broomrape (*Orobanche cumana* Wallr.) - Update on racial	Cadmium-potassium interrelationships in sunflower (*Helianthus annuus* L.) – H. SAMET, Y. CIKILI, N. C. ATIKMEN	Performance of sunflower hybrids in black cotton soils of Northern Karnataka, India – U. SHANWAD, SHANKERGOUD I, S. N. SUDHAKARBABU, V. KULKARNI, GOVINDAPPA MR, VIJAYKUMAR G.	Approaches for improvement of resistance to powdery mildew in sunflower (*Helianthus annuus* L.) – S. MULPURI, K. PALCHAMY, C. R. SANKARANENI, V. KODEBOYİNA

13^{50} -14^{10}	composition and distribution, host resistance and management	Effects of Micro Nutrients (Fe, Zn, B and Mn) on Yield and Yield Components of Two Sunflower (*Helianthus annuus* L.) Cultivars in Urmia Condition – A. RAHIMI, J. JALILIAN	Modeling sunflower fungal complex to help design integrated pest management strategies - AUBERTOT J. N., MESTRIES E., M. A. VEDY-ZECCHINI, P. DEBAEKE	Genetic engineering studies on sunflower- M. E. ÇALIŞKAN, S. DAS DANGOL
14^{10} -14^{30}	Testing annual wild sunflower species for resistance to *Orobanche cumana* Wallr – S. TERZIĆ, B. DEDIĆ, J. ATLAGIĆ, S. JOCIĆ, D. MILADINOVIĆ, M. JOCKOVIĆ	Quantification of drought tolerance levels of sunflower inbred lines by means of *chlorophyll*-a fluorescence - A. S. BALKAN, NALCAIYI, S. CULHA ERDAL - O. GUNDUZ, V. PEKCAN, O. ARSLAN, N. CICEK, Y. KAYA, Y. EKMEKCI	Escape to tiny bug (*Nysius simulans* Stål) attack across planting date adjustment in sunflower hybrid seed crops from southern BuenosAires province, Argentine – J. RENZI, O. REINOSO, M. BRUNA, M. AVALOS, M. CANTAMUTTO	***Invited Speaker*** **DR NICOLAS LANGLADE** Genome-wide association of oil yield plasticity to drought, nitrogen and chilling stresses in sunflower
14^{30} -14^{50}	Determination of superior hybrid combinations in sunflower and testing of their resistance to broomrape (*Orobanche cumana* Wallr.) In infested areas – O. GÜNDÜZ, A. T. GOKSOY	The effect of climate factors and climate change on the yield of sunflower (*Helianthus annuus* L.) in Marmara region – H. GURKAN, H. BULUT, N. BAYRAKTAR, M. DEMIRCAN, O. ESKİOĞLU, N. KOÇAK	Current Situation, Problems and Solutions of Sunflower in the Central Anatolian Region – C. YAVUZ, S. CALISKAN	
14^{50} -15^{00}	Discussion	Discussion	Discussion	Discussion
15^{00} -15^{30}	Coffee break	Coffee break	Coffee break	Coffee break
15^{30} -17^{00}	***6th Session Chair: DR CHAO CHIEN JAN***	***6th Session: Chair: DR GERALD SEILER***	***6th Session Chair: PROF DR MICHELLE GILLEY***	***6th Session Chair: DR STEPHANE MUNOS***
15^{30} -15^{50}	***Invited Speaker*** **DR GORAN MALIDZA** Integrated weed management in sunflower: Challenges and opportunities	Effects of Naphthalene Acetic Acid and N6-Benzyladenine on Androgenesis in *Helianthus annuus* L. Anthers - S. DAYAN, H. ARDA	Microbial Dressing of Sunflower Seeds with *Trichoderma harzianum* KUEN 1585 – Y. S. YONSEL, M. SEVİM	QTL mapping for broomrape (*Orobanche cumana* Wallr.) resistance in sunflower – I. CELİK, D. ZARARSIZ, A. FRARY, S. DOGANLAR
15^{50} -16^{10}		Do cell wall proteins affect the setting of grains and their potential weight in sunflower? – D. CALDERINI, S. VASQUEZ, F. CASTILLO, P.	Green and brown bridges aid survival of multiple *Diaporthe / Phomopsis* species with a range of virulences on sunflower, soybeans,	Determination the genetic characterization of different lines of sunflower (*Helianthus annuus* l.)by using genetic resources

		MONTECINOS, A. CLAUDE, C. LIZANA, R. RIEGEL	mungbeans and other crops in Australia. – S. THOMPSON, S. NEATE, Y. PEI TAN, R. SHIVAS, E. AITKEN	based on SSRs (Simple Sequence Repeat) – D. BASALMA, M. PASHAZADEH
16[10]-16 [30]	Advancements in Clearfield® Plus Sunflower Hybrid Variety Development – B. WESTON, M. PFENNING, C. NIETO, P. ANGELETTI, E. SAKIMA	The Estimating Drought Stress Tolerances of Sunflower Inbred lines under controlled environmental conditions – O. ARSLAN, A. S. BALKAN NALCAIYI, G. EVCI, V. PEKCAN, I. M. YILMAZ, S. ÇULHA ERDAL, N. CICEK, Y. KAYA, Y. EKMEKCI	Evaluation of Sunflower (*Helianthus annuus* L.) Hybrids for Photothermal Units Accumulation, Oil Yield, Oil Quality and Yield Traits under Spring Planting Conditions of Haripur, Pakistan – A. QAYYUM, I. SULTAN, S. U. KHAN, Y. BIBI, A. MEHMOOD, A. SHER, M. A. JENKS	Study of the genomic diversity of *Verticillium sp*. capable of colonizing sunflower. How knowledge of pathogen genetic structure can be combined with classical breeding approaches to guide it – H. MISSONNIER, F. LUIGI, L. GWENAELLE, DAYDÉ J, J. ALBAN, THOMMA B. PHJ
16[30]-16[45]	Discussion	Discussion	Discussion	Discussion
16[45]-18 [00]	***Poster Session***	***Poster Session***	***Poster Session***	***Poster Session***
19 [30] -	**Dinner Party**	**Dinner Party**	**Dinner Party**	**Dinner Party**

	01. 06.2016 WEDNESDAY	**01. 06.2016 WEDNESDAY**	**01. 06.2016 WEDNESDAY**
09[30]-11 [00]	***7th Session Chair: DR MIGUEL CANTAMUTTO***	***REGISTRATION***	
09[30] -09[50]	The effects of applied herbicides on yield and oil quality components of two oleic and two linoleic sunflower (*Helianthus annuus* L.) hybrids – F. ONEMLI, U. TETIK	***INTERNATIONAL SUNFLOWER OIL QUALITY SYMPOSIUM*** Opening Cerenomy	
09 [50]-10[10]	New virulences of *Orobanche cumana* appear in Romania - PARVU N., TEODORESCU A.	***Session Chair: PROF DR MEHMET EMIN CALISKAN*** ***Invited Speaker*** **Fabrice THURON -** "HO Oilseeds and Oils Market: Positioning Sunflower Today and Tomorrow	
10[10] -10[30]	Genetic characterization of the interaction between sunflower and *Orobanche cumana* - LOUARN J., M. C. BONIFACE, POUILLY N., VELASCO L., P. VINCOURT, B.	***Invited Speaker*** **Prof Dr Nurhan TURGUT DUNFORD** Sunflower Oil: A Premium Oil for Food Applications	

	PÈREZ-VICH, MUNOS S.		
10^{30}-10 ^{50}	Study of *Orobanche cumana* genetic diversity – M. COQUE, T. ANDRE, R. GIMENEZ, M. ARCHIPIANO, L. POLOVYNKO, M. C. TARDIN, C. JESTIN, B. GREZES-BESSET	***Invited Speaker*** **DR. LEONARDO VELASCO** Source and sink affect phytosterol concentration and composition of sunflower oil	
10^{50}-11 ^{00}	Discussion	Discussion	Discussion
11^{00} -11^{20}	Coffee break	Coffee break	Coffee break
11^{20}-12^{30}	***8th Session: Chair: DR LOREN H. RIESEBERG***	***8th Session: Chair: DR LEONARDO VELASCO***	***8th Session: Chair: PROF DR ZHAO JUN***
11^{20}-11^{40}	***Invited Speaker*** **DR LAURA F. MAREK** Sunflower Genetic Resources	Oil content and oil quality characteristics of linoleic and high-oleic sunflower varieties cultivated in Turkey – B. ASKIN, M. AFACAN, V. BİCER, Ö. KARADAS, İ. KONUK	Quality characteristics of roasted sunflower seeds during storage - M. B. BAHAR, F. SEYHAN, B. OZTURK, B. TOPAL, F. S. BAYRAKTAR
11^{40}-12 ^{00}		Determination of Textural, Rheological Properties and SFC, SMP Values of Oleogels Prepared Using Sunflower Oil – H. PEHLİVANOGLU, O. S. TOKER, H. IMAMOGLU, M DEMIRCI	Effect of different storage conditions on quality properties of raw and roasted sunflower kernels – F. SEYHAN, M. B. BAHAR, B. TOPAL, B. ÖZTÜRK, F. S. BAYRAKTAR
12^{00}-12 ^{20}	Four decades of sunflower genetic resources activities in India – M. DUDHE, S. MULPURI	Assessment of sunflower oil adulteration – A. CEVIK, A. UNVER	The Evaluation of Sunflower Harvest Waste as Silage Feed – S. BUYUKKILIC BEYZI, M. YILMAZ, Y. KONCA
12^{20}-12 ^{30}	Discussion	Discussion	Discussion
12^{30}-13 ^{30}	**Lunch (Courtesy of Edirne Commodity Exchange)**		
13^{30}-15 ^{30}	***9th Session Chair: DR ABELARDO DE LA VEGA***	***9th Session Chair: PROF DR NURHAN T. DUNFORD***	***9th Session Chair: PROF DR SEVGI CALISKAN***
13^{30}-13 ^{50}	***Invited Speaker*** **DR NADA HLADNI** Present status and future prospects of global confectionery sunflower production	The effects of vacuum and atmospheric deep-fat frying process on total frying-use time of sunflower oil and on french fries quality – E. DEVSEREN, D. TOMRUK, U. BAYSAN, M. KOC, H. KARATAŞ, F. ERTEKIN	Study of the characteristics of cultivated varieties of sunflower, regarding the production of high quality sunflower meal with dehulling process - S. DAUGUET, F. LABALETTE, F. FINE, P. CARRE, A.MERRIEN, J. P. PALLEAU
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14^{10}-14^{30}	Grain, kernel and hull characterization of oilseed and oilseed x confectionary genotypes- S. ZUIL, M. LAUREANO, P. ROCCA, M. DELLA MADDALENA	Application of artificial neural network on prediction of moisture content of the deep-fat frying of beef meatballs in sunflower oil-H.I. KOZAN, C. SARIÇOBAN, H. AKYÜREK	Some Antinutrients and in vitro Protein Digestibility of Home Processed Sunflower Seed Meal – M. KARWASRA, S. DHIYA
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15^{00}-15^{30}	Coffee break	Coffee break	Coffee break
15^{30}-17^{00}	***10th Session Chair: DR PIERRE CASADEBEIG***	***10th Session Chair: DR SUSAN THOMPSON***	***10th Session Chair: DR NICOLAS LANGLADE***
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15^{50}-16^{10}	The evaluation of annual wild *Helianthus* species for their morphological, phenological and seed chemical characteristics in field conditions – F. ONEMLI, G. ONEMLI	LC-DAD/ESI-MS/MS Characterization of Phenolic Compounds of Sunflower oil – H. KELEBEK, S. SELLI, A. S. SÖNMEZDAĞ, S. KESEN, G. GUCLU, O. KOLA	
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16^{45}-17^{45}	**ISA GENERAL ASSEMBLY**
17^{45} -18^{00}	***Closing Ceremony***
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13^{30}-17^{30}	Edirne City Tour
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	03.06.2016 FRIDAY
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CONTENTS

AN EMS MUTATION ALTERING OIL QUALITY IN SUNFLOWER INBRED LINE

Sandra Cvejić *, Siniša Jocić, Aleksandra Dimitrijević, Ivana Imerovski, Dragana Miladinović, Milan Jocković, Vladimir Miklič

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ABSTRACT

The main objective of this research was to increase genetic variability of sunflower in terms of oil quality and productivity using induced mutations. A preliminary sensitivity test was performed to establish optimal ethyl-methane-sulphonate (EMS) doses for seed treatement. The results showed that high EMS concentrations (0.5-2.5%) caused low survival rates, therefore lower EMS doses were used. Thousand seeds of the sunflower high-oleic inbred line L31 were treated with 0.1% solution of EMS to induce mutations. In the M_2 generation, seeds were screened for fatty acid composition and alterations occured in individual plants. In the next generation a putative mutant line, ML31-1, was isolated with significantly lower oleic acid content compared to the wild type L31 grown in the same year. We assumed that heterozygous mutation occurred, manifested by changing a dominant allele *Ol* to the recessive *ol*. After self-polination in the next generation the segeregation of oleic acid was from 346.6 to 949.1 g/kg and of linoleic acid from 39.9 to 339.3 g/kg. In subsequent generations, individual selection and evaluation of progenies continued in several directions depending on the content of oleic acid: low, increased or high. The stable progenies were evaluated in micro-plot tests for seed yield and other agronomic traits in comparison with their respective wild type.

Key words: sunflower, induced mutation, ethyl-methane-sulphonate, fatty acids, oleic acid

INTRODUCTION

Sunflower oil has been traditionally appreciated as a high-quality commodity in the world oil market (Fernandez-Martinez et al., 2009). Standard sunflower oil is liquid at room temperature due to high content of unsaturated fatty acids. The most abundant is polyunsaturated linoleic acid (C 18:2), about 550-700 g/kg, followed by monounsaturated oleic acid (C 18:1) with 200-250 g/kg. Keeping up with the trends of the food and other industries, sunflower breeders have been able to significantly change the quality of the oil (Cvejić et al., 2014). The high-oleic sunflower hibrids have increased content of oleic acid 800 g/kg and more, compared to a standard type of sunflower. Oil of the high-oleic hybrids has excellent nutritional properties, is a suitable raw material for many derivatives of the chemical industry and for the production of high quality biodiesel, is more favorable because of higher oxidative stability, more resistance to heating and heart-healthy properties (Haddadi et al., 2011). Sunflower breeders have developed a large number of high-oleic hybrids because of the rapidly increasing interest of oil industry (Škorić et al., 2008). However, selection pressure to one particular trait can influence variability of other traits.

Sunflower genetic variability is often limited, as its genetic base of available inbred lines is narrowed. Genetic variability can be broadened by interspecies hybridization with wild species and mutation breeding (Cvejić et al., 2015). The great variability arising after mutagen treatment offers breeders unique challenge for the development of new genetic combinations (Velasco et al. 1999). Induced mutations have been applied for the past 40 years to produce mutant cultivars in sunflower by changing plant characteristics that significantly increase seed yield and quality (Cvejić and Bado, 2009). The first high-oleic sunflower variety Pervenec was obtained by induced mutagenesis by

seed treatment of the variety VNIIMK 8931 with the solution of dimethyl sulfate (DMS) and selection for increased content of oleic acid over 840g/kg (Soldatov 1976). Worldwide, Pervenec is used as a high-oleic trait donor in breeding programs. There are publications about other sources of high-oleic mutants with 800g/kg of oleic acid (Ivanov et al. 1992) and with 900g/kg of oleic acid (Andrich et al., 1992). Recently, the new high oleic sunflower mutant was obtained which ultra-high oleic content was not affected by temperature during grain filling, representing an advantage over the high oleic Pervenets and traditional genotypes (Leone et al. 2013, Alberio et al. 2016). The mode of inheritance of oleic acid content proved to be complex and has been studied by numerous authors, but there is no unanimity among scientists over the number of genes which control this trait (Fick, 1984; Urie, 1984; 1985; Miller et al., 1987; Fernandez-Martinez, 1989; Fernandez et al., 1999; Demurin and Škorić, 1996; Velasco et al., 2000; Lacombe and Berville, 2001; Lacombe et al., 2002; Perez-Vich et al., 2002; Vares et al., 2002; Schuppert et al., 2006). The common conclusion of all studies is that the presence of gene *Ol* is crucial for creating high oleic sunflower genotypes, while number and function of genes controlling this inheritance of this trait remain to be determined.

The main objective of this research was to increase genetic variability of sunflower inbred line in terms of oil quality and productivity. The first step was to assess the efficiency of ethyl-methane-sulphonate (EMS) mutagenic treatments, while the second is to detect mutant lines with different (changed) oil quality; this would provide new genetic variability and better crop productivity and stability.

MATERIAL AND METHODS

Plant material: Sunflower inbred line L31 (wild type) was used for mutagenesis. Line was developed in Institute of Field and Vegetable Crops in Novi Sad, Serbia. This line has over 800 g/kg oleic acid and has potential for further improvement of productivity and stability.

Mutagenic treatment: Ethyl-methane-sulphonate (EMS) mutagenesis of seeds from line L31 was performed in the Joint FAO/IAEA Laboratories in Seibersdorf, Austria. In order to determine the survival rate, fifty seeds were treated with 5 concentrations of EMS solution, 0.5, 1.0, 1.5, 2.0 and 2.5% (v/v), respectively; treatment concentrations were based on studies of other species (Kodym and Afza, 2003). Before the treatment, seeds were transferred to nylon meshes and pre-soaked in distilled water for 24 hours at room temperature. Seeds were then incubated in 200 ml of sodium phosphate buffer (0.1 M, pH 7.4) with gentle shaking (100 rpm) and different EMS concentrations were added. Incubation lasted 4 h. After the EMS treatment, the seeds were washed in distillated water several times. The control, non-mutagenized seeds were treated similarly, except for exposure to the mutagen. All treated seeds and the controls were sown in boxes using the flat method (Gaul, 1963) in a glasshouse under controlled environmental conditions (22-35ºC, lighting of 12h photoperiod). The parameter used to assess the dose response was the survival rate. The number of viable seedlings were calculated after a week of sowing and survival rate was determined by calculating number or survived seedlings per total number of planted seeds. Based on these results, batches of seeds were treated with two concentration of EMS, 0.1% (v/v) and 0.25% (v/v), respectively, and planted in the field.

Selection method: After the mutagenesis, M_1 seeds were planted in the nursery field of the Institute of Field and Vegetable Crops in Rimski Šancevi, Novi Sad, Serbia and after self-pollination of M_1 surviving plants, M_2 seeds were harvested. Seeds from each head were screened for fatty acid composition. Seeds of the wild type were grown and screened at the same time/. Mutants with altered fatty acid content were selected by screening. Seed from selected plants were planted next year in the field and after self-pollination, the M_3 seeds were collected. In next

generations plants were selected by pedigree method and seeds were screened for fatty acid composition. Fatty acid composition was measured by gas chromatography.

Agronomic evaluation: Selected mutants (M_6) and wild type were planted in comparative trial. The trials were organized in randomized block design with three replicates. Following traits were analyzed: days to flowering (from plant emergence to full flowering - UPOV - stage F3.2), plant height (10 plants per replication), seed yield per plant, thousand seed weight, oil content (NMR) and fatty acid composition by gas chromatography (AOCS Official Method Ce 1-62, 1993).

Statistical analysis: The statistical data analysis of mutant generation was performed using Statistica 12 (StatSoft, DEL, USA). The selection progress in successive generations is illustrated in table and figures. Statistically significant differences between examined traits was determined by of t-test? In order to compare distributions of oleic and linoleic acid among mutant generations it was necessary to make corrections for their fluctuation over the years (Spasibionek, 2006).

RESULTS AND DISCUSSION

In order to obtain optimal concentration of EMS solution, seeds were treated with five different doses. The effect of treatment was evaluated by calculating the survival rate. The survival rate varied from 25% (2.5% EMS solution) to 32% (0.5% EMS solution) in the glasshouse (Table 1). This drastical reduction of survival rate showed that all five doses were too high for mutagenic treatment. For that reason further bulk treatments were adjusted with 0.1 and 0.25% of EMS. Depending on the concentration of EMS treatment, the survival rate was 86% (by use of 0.1% EMS solution) and 31% (by use of 0.25% EMS solution) of the M_1 seedlings growing in the field (Table 1). Since the plants treated with 0.25% EMS solution had poor seed set (19.2%), further analysis were based on plants treated with 0.1% EMS solution. In general, results of the sensitivity test showed high frequency of lethality leading to the conclusion that less drastic EMS concentrations should be used for sunflower inbred line L31 seed mutation induction. Generally, optimal EMS concentration for mutation induction differs not only between plant species, but also between different genotype of the same crop. Osorio et al. (1995) reported that EMS concentration of 70m*M* (0.87% EMS) was used to obtain mutagenic sunflower line CAS-3. In *Arabidopsis thaliana*, the LD50 rate determined for Ler and Cor-0 seeds was 0.2% EMS for 16h and 0.13-0.25% for 12.5h, respectively (Jander et al., 2003). The LD50 rates for sugar beet seed balls were 1% EMS for 12h (Hohmann et al., 2005).

Table 1. Results from EMS treatment.

EMS Treatments	No of treated seeds	M_1 seedlings - Survival (%)	Sterility (%)	Seed set (%)
Glasshouse				
0.5%	50	32		
1%	50	30		
1.5%	50	28		
2%	50	27		
2.5%	50	25		
Total	250			
Field				
0.1%	500	86.0	0.0	75.6
0.25%	500	31.0	0.4	19.2
Total	1000	58.5	0.2	47.4

Since no mutant selection is recommended in M_1, as mutation may remain masked or undetectable due to chimerism presence (Bado et al. 2015), M_2 generation of 0,1% EMS-mutagenized population was developed. To isolate the mutants, 378 individually harvested M_2 seed stocks were screened for fatty acid composition and alterations occured in individual plants. These individual plants were planted in the next generation and the mean content of oleic acid in the seed oil decreased from 867 to 603 g/kg while mean linoleic content increased from 40 to 305 g/kg. Mutant line, designated ML31-1, was identified (Table 2). Mutant line had significantly changed oleic acid content compared to the wild type, L31, grown in the same year. We assumed recessive mutation occurred, manifested by changing a dominant allele *Ol* to the recessive *ol*, especially due to the fact that the effect of recessive gene is manifested in the later generations (Knowles, 1989). For that reason, seeds were collected from each ML31-1 plant and used as a source of segregating mutant plants.

Table 2. Oleic and linoleic acid concentrations (g/kg) in the seed oils of mutants (ML31-1, ML-31-11, ML31-12, ML31-13) and the wild type (L31) of sunflower in five M generations.

Gen eration	No of plants	Fatty acid (g/kg)	Mutants				Check	CV			
			ML31-1	ML31-11	ML31-12	ML31-13	L31	ML31-1	ML31-11	ML31-12	ML31-13
M_2	378	Oleic	790.0** (590.0[a])				821.0	22.32			
		Linoleic	144.0** (325.0[a])				94.0	25.01			
M_3	45	Oleic	603.0**				867.0	40.82			
		Linoleic	305.0**				40.0	45.84			
M_4	163	Oleic		519.9**	649.9**	863.6	850.8		12.25	22.55	8.24
		Linoleic		339.3**	231.5**	39.9	40.1		19.88	20.01	12.32
M_5	275	Oleic		514.7**	624.0**	855.0	832.5		12.26	11.22	4.86
		Linoleic		359.3**	269.0**	57.0	50.9		15.48	12.83	8.38
M_6	308	Oleic		482.0**	613.0**	887.0	867.0		9.62	10.21	8.66
		Linoleic		391.3**	270.0**	13.0	40.0		8.29	10.11	8.73

*,**significant at P=0.05 and P=0.01, respectively

[a]meaen value of individual plants

In the next generation (M_3), it was convenient to maintain mutant selection as in segregating population. After harvesting seeds were screened for fatty acid composition. The content of oleic and linoleic acid was significantly changed comparing to the wild type (Table 2). The segregation of oleic acid ranged from 346.6 to 949.1 g/kg and of linoleic acid from 39.9 to 339.3 g/kg (Fig. 1 and 2). In subsequent generation (M_4), individual selection and evaluation of progenies continued in several directions depending on the content of oleic acid: low, increased or high. We identified three subsequent mutants, designated ML31-11, ML31-12 and ML31-13.

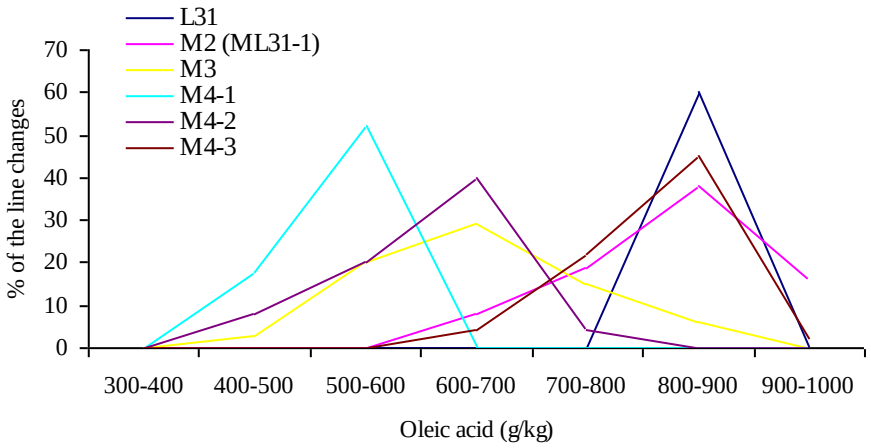

Fig.1. Distribution of oleic acid content (g/kg) in four M generations of sunflower mutant ML31-1 and subsequent mutants ML31-11 (M4-1), ML31-12 (M4-2) and ML31-13 (M4-3) compare to wild type L31

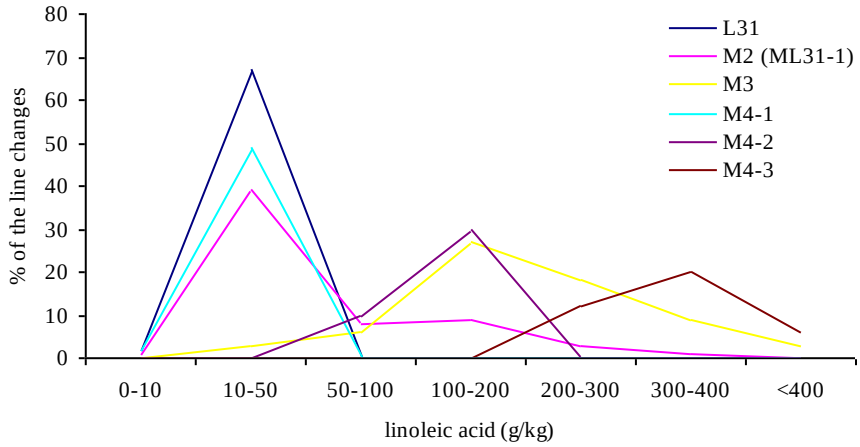

Fig.2. Distribution of linoleic acid content (g/kg) in four M generations of sunflower mutant ML31-1 and subsequent mutants ML31-11 (M4-1), ML31-12 (M4-2) and ML31-13 (M4-3) compare to wild type L31

In M_6 generation subsequent mutants ML31-11, ML31-12 and ML31-13 were evaluated and showed significant differences in one or more characteristics in regards to wild type (Table 3). Due to fatty acid content, mutant lines ML31-11 and ML31-12 had significantly lower concentration of oleic acid and significantly higher concentration of linoleic acid compared to the wild type. The content of oleic acid was higher in ML31-12 mutant line than in ML31-11. The thousand-seed-weight of these mutant lines was significantly higher than of the wild type. With respect to oleic acid content, values obtained were similar between the wild type and the mutant ML31-13, however, other examined traits such as oil content, thousand-seed-weight and seed yield were significantly higher in mutant line than the wild type (Table 3). This improvement represents the progress of wild type (line L31) thought mutation breeding since the seed yield and its components are the most important traits in sunflower production. Two mutant lines (ML31-12, ML31-12) exhibited highly significant increase in seed yield compared to the wild type. The oil content in the seed is closely linked to seed yield, which is the main purpose of sunflower growing (Škorić, 2012). Significant increase in oil content was observed in the mutant line ML31-13. This obtained increase is a very notable result, since no drastic mutation has been reported for seed oil content in sunflower (Vranceanu and Iuoras, 1991, Cvejić et al., 2015).

Table 3. Comparison between mutants ML31-11, ML31-12, ML31-13 and wild type L31 for some agronomic traits and fatty acid composition investigated in the field trials.

Traits	Mutants			Wild type
	ML31-11	ML31-12	ML31-13	L31
Full flowering (days)	58.0(±0.33)	57.0(±0.33)	58.0(±0.67)	57.0(±0.01)
Plant height (cm)	134.8(±2.10)	126.6(±0.62)	133.2(±1.21)	133.6(±0.15)
Seed yield (g/plant)	25.9(±0.13)	29.5**(±0.08)	30.1**(±0.32)	24.7(±0.05)
Thousand-seed-weight (g)	63.61**(±0.13)	63.13**(±0.11)	64.79**(±0.15)	59.5(±0.12)
Oil content (%)	50.56(±0.13)	50.09(±0.14)	54.1**(±0.13)	50.4(±0.10)
Palmitic acid (g/kg)	54.3(±0.20)	48.2(±0.08)	34.8(±0.01)	39.2(±0.01)
Stearic acid (g/kg)	59.5(±0.41)	57.6(±0.02)	50.8(±0.10)	49.6(±0.08)
Oleic acid (g/kg)	482.0**(±1.13)	613.0**(±2.23)	887.0(±2.40)	867.0(±3.08)
Linoleic acid (g/kg)	391.3**(±2.14)	270.0**(±0.21)	13.0**(±0.01)	40.0(±0.70)
Linolenic acid (g/kg)	1.1(±0.00)	1.0(±0.00)	1.2(±0.01)	1.0(±0.00)

*,**significant at P=0.05 and P=0.01, respectively

Induced mutagenesis lead to genetically inherited variability of sunflower inbred lines in terms of oleic and linoleic acid content, which will be more suitable for use in breeding programmes. Further studies will include identification of molecular changes that led to changes in oleic acid content in new mutant lines.

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