Field Crops Studies

Volume X
No. 1

2016

Изследвания върху полските култури

Том X
Книжка 1

2016

Издател: Добруджански земеделски институт
Редакция: Добруджански земеделски институт
гр. Генерал Тошево, 9520
тел.: +359 58 / 603 125; факс: +359 58 / 603 183
e-mail: fcs@dai-gt.org; http://fcs.dai-gt.org/
Корица: Катя Делчева, Стефан Димитров
Дизайн и предпечат: Катя Делчева, Стефан Димитров
Печат: "Нилекта Принт" ООД - гр. Добрич (+359 58 600 299)
ISSN 1312-3882

Publisher: Dobrudzha Agricultural Institute
Address: Dobrudzha Agricultural Institute
General Toshevo 9520
phone: +359 58 / 603 125; fax: +359 58 / 603 183
e-mail: fcs@dai-gt.org; http: //fcs.dai-gt.org/
Cover design by Katia Delcheva& Stefan Dimitrov
Text design and typeset by Katia Delcheva & Stefan Dimitrov
Printed by Nilekta Print Ltd. - Dobrich (+359 58 600 299)
ISSN 1312-3882

Изследвания върху полските култури 2016, Том X - 1
Field Crops Studies, 2016, Vol. X - 1

PRODUCTION POTENTIAL OF EXPERIMENTAL IMI RESISTANT SUNFLOWER HYBRIDS

Daniela Valkova, Emil Penchev, Valentina Encheva, Nina Nenova
Dobrudzha Agricultural Institute – General Toshevo, 9520, Bulgaria

ABSTRACT

Valkova, D., E. Penchev, V. Encheva, N. Nenova, 2016. Production potential of experimental IMI resistant sunflower hybrids. FCS 10(1):97-102

The distinctions between 34 IMI-resistant experimental hybrids were studied on the characters seed yield, seed oil content, seed oil yield, plant height, head diameter and climate conditions influence applying two-factor analysis of variance. Plasticity of hybrid combinations was established by studying their reaction to the variable climatic conditions. It was determined that hybrids 1111A x 146R; 1111A x 185R; 1111A x 437R; 1111A x 481R; 1111A x 488R; 1111A x 514R and 1111A x 360R exceeded the mean standard on the characters seed yield and seed oil content with the highest statistical authenticity P=0,001. The tested hybrid combinations were affected equally by the climatic conditions in the respect of the character seed oil content. The strongest was the influence of environmental conditions related to the characters seed yield and plant height.

Key words: sunflower-imidazolinone resistance-hybrids-seed yield- resistance.

РЕЗЮМЕ

Вълкова, Д., Е. Пенчев, В. Енчева, Н. Ненова, 2016. Продуктивен потенциал на експериментални IMI устойчиви хибриди слънчоглед. FCS 10(1):97-102

Двуфакторен дисперсионен анализ е приложен за изучаване на 34 IMI-устойчиви експериментални хибриди слънчоглед по признаците добив семе, съдържание на масло в семената, добив масло, височина на растенията, диаметър на питата и влияние на климатичните условия. Пластичността на хибридните комбинации е установена чрез проучване на реакцията им към вариращите климатични условия. Установено бе, че хибридите 1111A x 146R; 1111A x 185R; 1111A x 437R; 1111A x 481R; 1111A x 488R; 1111A x 514R и 1111A x 360R превишават средния стандарт по признаците добив семе и съдържание на масло в семената с най-висока статистическа достоверност P=0,001. Изпитаните хибридни комбинации се влияят еднакво от климатичните условия по отношение на признака съдържание на масло в семената. Най-силно е влиянието на условията на средата по отношение на признаците добив семе и височина на растенията.

Ключови думи: слънчоглед-устойчивост на имидазолинон-хибриди-добив семе-устойчивост.

INTRODUCTION

Sunflower is the main oil crop in Bulgaria. The planting areas have increased in recent years because of higher profitability, low input requirements and better exporting possibilities, but higher rates of disease and pests have severely limited the sunflower production in some years. Significant results have been recently achieved in sunflower breeding for tolerance to imidazolinone (IMI) herbicides. Using IMI herbicide resistant hybrids gave farmers, the opportunity to control broadleaf weeds such wide spread Xanthium, Cirsium sp. Imidazolinone herbicides control a broad spectrum of grass and broadleaf weeds in imidazolinone-tolerant sunflower, including weeds that are closely related to the crop itself and the key parasitic weed broomrape (Tan *et al*., 2005).

An imidazolinone-tolerant wild sunflower population that was discovered in soybean field in Kansas, USA in 1996 (Al-Khatib et al. 1998) was used as a source for insertion of imidazolinone-tolerance gene into the first imidazolinone-tolerant lines (Al-Khatib and Miller 2000).Two lines (IMISUN-1 and IMISUN-2) were developed with resistance to imidazolinone herbicides (Al-Khatib and Miller 2000). This was followed by the release of public IMISUN lines in 1998. The development of resistant IMISUN sunflower hybrids depends on both inbred lines, having IMI-resistant genes, because this resistance was controlled by two genes: a major gene with semi dominant type of gene action (*Imr1*) and second gene (*Imr2*) with a modifier effect (Bruniard and Miller, 2001; Sala *et al*., 2012).

Sala *et al*. (2008a, b) reported for obtaining a new source of IMI resistance, CLHA-PLUS, developed by induced mutations (ethyl-methanesulfonate mutagenesis) and selection. *CLHA-PLUS* was different from *Imr1* at the molecular level and was controlled by expression of the partially dominant nuclear allele *AHAS1-3*. This *CLHA-PLUS* gene has higher IMI resistance than the *Imr1* and *Imr2* genes and higher oil content in sunflower hybrids. This was widely known as the Clearfield System, a trademark of BASF *Co* (Evci *et al*., 2012; Skoric, 2012; Kaya *et al*., 2013; Kaya, 2014). In recent years, IMI-Plus sunflower hybrids have been developed in many countries.

The aim of this investigation was to test experimental IMI resistant sunflower hybrids, compare their seed yield, oil content with standards and choose those with highest exceeding.

MATERIAL AND METHODS

The investigation was carried out in 2014 and 2015. Two sterile mother lines and twenty-seven restorers with *CLHA-PLUS* gene were used. They were the result of implementation of long-term research program for developing herbicides resistant hybrids at DAI. The parental lines were characterized by morphological uniformity and very good combining ability. Some of them were resistant to *Plasmopara helianthi*. The standards, included in this testing were Adagio CX, LG5661 CL. Hybrid plants were treated at phase 3-5 pair of true leaves with the herbicides - Pulsar 40 (120 ml/da) and Stomp 330 EU (230 ml/da). Hybrids were tested at the experimental breeding fields of DZI-General Toshevo in a randomized block method in three repetitions, as the area of each repetition was 10 m^2 (Barov and Shanin, 1965). Phenological characters, conformed to UPOV characteristics, were determined. The seed oil content was determined on the method of Rushkovskii (1957). The seed set (%) was calculated as a correlation between the number of inseminated disk florets to the total number of disk florets in one inflorescence. Phytopathological evaluations of F1 hybrids were carried out in laboratory conditions and in artificial infection plot. Evaluation for resistance to downy mildew (*Plasmopara halstedii* Farl. Berleseet de Toni) was carried out on the method of Vear and Tourvieille (1987). Evaluation for resistance to grey spots on sunflower (*Phomopsis/Diaporthe helianthi* Munt.-Cvet. et al.) was carried out on the method of Encheva and Kiryakov (2002) in field conditions on artificial infection plot. Evaluation for resistance to black spots on sunflower (*Phoma macdonaldii* Boerema / *Phoma oleracea* var. *helianthi-tuberosi* Sacc) was carried out on the method of Fayralla i Maric (1981) in field conditions on artificial infection plot.

The obtained data were analyzed by ANOVA 3, a statistical tool, used to develop and confirm an explanation for the obtained experimental data**.** The ANOVA F-test is known to be nearly optimal in the sense of minimizing false negative errors for a fixed rate of false positive errors. The two-way analysis of variance was applied. It examines the influence of two different categorical independent variables on one continuous dependent variable. The two-way ANOVA not only aims at assessing the main effect of each independent variable, but also, if there is any interaction between them. These two factors are YEAR (Y) and HYBRID (H).

RESULTS AND DISCUSSION

Rising temperature and altered soil moisture due to climate change is believed to decrease the yield of food crops over next 50 years. Drought is one of the environmental factors, limiting plant growth and the productivity of many crops. Sunflower is considered as comparatively drought tolerant crop. It has the ability to extract water from deeper in the soil profile than other crops, and thus it can extract more water from each soil layer. The period of investigation 2014-2015 was covered by difference on soil moisture supply. For the aim of the study, some meteorological data were summarized and analyzed (fig.1). The meteorological conditions during the vegetation period of sunflower were characterized by quantities of rainfall (mm) for the period April-October and average diurnal temperature range for that period. The agricultural and meteorological conditions were variable and that affected the plants growth. The analysis of the obtained data showed that the experimental hybrids were tolerant to both low and high temperatures, but more tolerant to low temperatures. A critical time for water stress was the period 20 days before and 20 days after flowering.

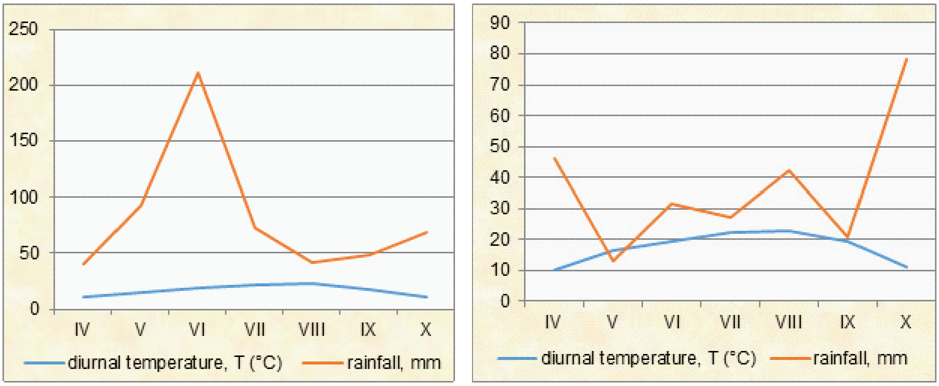

Figura 1. Temperature range (^{0}C) and rainfall (mm) during 2014-2015.
Фигура 1. Температура (^{0}C) и валежи (mm) през 2014-2015.

Sunflower is very responsive to rainfall received during June and into September - starting just prior to flowering and continuing through seed fill. The seed yield was strongly affected when water deficiency appeared during flowering and in the following stages. A critical time for water stress was the period from beginning of button formation until the end of flowering.

If occurring in that period the drought causes substantial reduction of yield and yield components. That's why the seed yield of experimental hybrids and the mean standards Adagio-CX and LG 5661 CL were significantly lower in 2015 than in 2014 (fig.2, 3).

The mean standard for seed yield of replications in 2014 was 161,6 kg/da. Just seven of the tested hybrids exceeded it with 0.7% to 5,6%. The highest results showed the hybrids 1111A x 3060 R and 1111A x 185 R, which seed yield was respectively 172,5 kg/da and 180,8 kg/ha. They also exceeded the mean standard of oil yield with 6,8% and 11,8% respectively. The mean standard for seed yield of replications in 2015 was 136,7 kg/da. The lower seed yield was due to the lack of water supply in the soil and rainfall during the vegetation period of plants. The exceeding of seed yield was 3,6% to 12,5% for some of the studied hybrids. The highest exceeding was established for hybrids 1111A x 3060 R, 1111A x 185 R and 1111A x 146 R. The exceeding regarding oil yield varied from 8,1% to 15,2%. The highest seeds oil content was determined for hybrid 1111A x 185 R – 47,5%, followed by 1111A x 437 R – 45,5%.

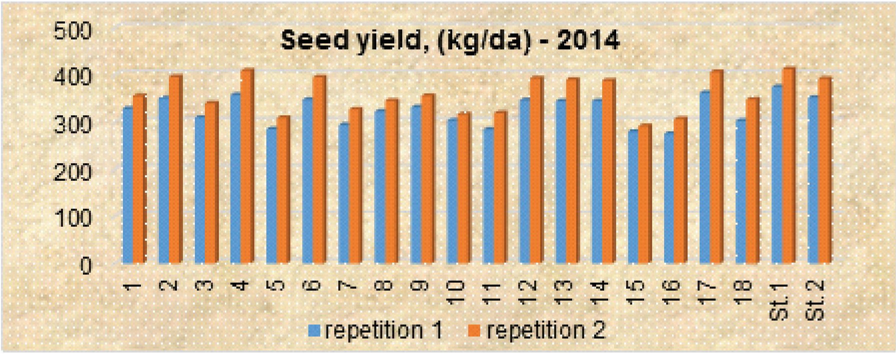

Figura 2. The seed yield in 2014 of 18 experimental hybrids and standards
Фигура 2. Добив семе през 2014 от 18 експериментални хибриди и стандарти

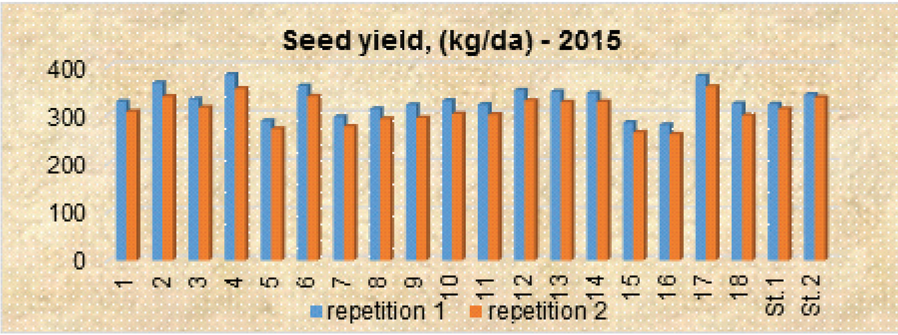

Figura 3. The seed yield in 2015 of 18 experimental hybrids and standards
Фигура 3. Добив семе през 2015 от 18 експериментални хибриди и стандарти

Two-way analysis of variance was applied for two independent variables with aim to determine three sets of hypothesis. The null hypotheses for each of the sets are the follow: 1.The population means of the first factor are equal. 2. The population means of the second factor are equal. 3. There is no interaction between the two factors.

The idea is that there are two variables, factors, which affect the dependent variable. Each factor will have two or more levels within it, and the degrees of freedom for each factor is one less than the number of levels. The summarized results are demonstrated on table 1. There is an F-test for each of the hypotheses, and the F-test is the mean square for each main effect and the interaction effect divided by the within variance. The numerator degrees of freedom come from each effect, and the denominator degrees of freedom is the degrees of freedom for the within variance in each case. The critical value of F is a function of the degrees of freedom of the numerator and the denominator and the significance level. If F > Fcrit, the null hypothesis is rejected. The compendious results were on table 1.

Table 1. Dispersion analysis of variance for some characters of tested hybrids, connected to seed yield.

Таблица 1. Дисперсионен анализ на варирането по някои признаци на изпитваните хибриди, свързани с добив семе.

Characters Признаци	MSh	MSy	MS yxh	MS error	LSD 5%	LSD 1%	LSD 0,1%
Seed oil content Съдържание на масло в семената	8,35**	69,4***	1,3	0,94	0,62	0,83	1,07
Oil yield Добив масло	1183,2***	4813,8***	80,4	61,4	5,06	6,71	8,67
Seed yield Добив семе	3773,,1**	9730,7***	320	450	13,7	18,2	23,5
Plant height Височина на растенията	4194,3	2331***	1287,9***	33,5***	3,7	4,8	6,2
Head diameter Диаметър на пита	144,7***	30,1**	18,1*	2,9	1,1	1,4	1,8

** - statistical significant by p=0.01 , *** - statistical significant by p=0.001

An expressive interaction existed between year and hybrid in their influence on the seed yield and F criteria pointed that the hypothesis for significance of compound effects was rejected. As the compound effects of these two factors were significant, it could be accepted that the influence of factors year and hybrid on the seed yield was significant.

Table 2. Phytopathological evaluation of F_1 hybrids for resistance to *Pl. helianthi* and *Orobanche cumana.*

Таблица 2. Фитопатологична оценка на F_1 хибриди за устойчивост към *Pl. helianthi* и *Orobanche cumana.*

Resistance, % Устойчивост, %	Experimental hybrids Експериментални хибриди	
Resistance 100 % to *Pl. helianthi* Novot. and 76-99% to *Orobanche cumana* Wallr. Устойчивост 100 % към *Pl. helianthi* Novot. и 76-99% към *Orobanche cumana* Wallr.	1111 A x 146 R 1111 A x 437 R	1111 A x 185 R 1111 A x 3060 R
Resistance 76-99% to *Pl. helianthi Novot*. and *Orobanche cumana* Wallr. Устойчивост 76-99% към *Pl. helianthi Novot*. и *Orobanche cumana* Wallr.	1111 A x 175 R 1111 A x 488 R	1111 A x 481 R 1111 A x 524 R

The reaction of experimental hybrids to the pathogens *Plasmopara helianthi, Phomopsis helianthi, Phoma macdonaldii* and the parasite broomrape (*Orobanche cumana*) was studied with aim to establish the resistant ones (Tables 2-3). The hybrid combinations 1111 A x 146 R, 1111 A x 185 R and 1111 A x 437 R were resistant (100%) to downy mildew and the parasite broomrape. They were characterized with resistant type of reaction to the pathogens caused grey and black spots on sunflower and with up to 49% oil content in seeds. Their vegetation period was 115-118 days. Certain resistance to these two pathogens was established for the other hybrids, obtained with participation of resistant to these pathogens restorer lines. These hybrids could be successfully included in the sunflower breeding programs for developing new resistant lines.

Table 3. Phytopathological evaluation of F_1 hybrids for resistance to *Phomopsis helianthi Munt.-Cvet. et all.* and *Phoma macdonaldii Boerema.*

Таблица 3. Фитопатологична оценка на F_1 хибриди за устойчивост към *Phomopsis helianthi Munt.-Cvet. et all.* и *Phoma macdonaldii Boerema.*

Type of reaction Тип на реакция	Experimental hybrids Експериментални хибриди	
Resistant to *Phomopsis helianthi* and *Phoma macdonaldii* Устойчив към *Phomopsis helianthi* и *Phoma macdonaldii*	1111 A x 129 R 1111 A x 185 R	1111 A x 146 R 1111 A x 437 R
Mid. resistant to *Phomopsis helianthi* and *Phoma macdonaldii* Ср. Устойчив към *Phomopsis helianthi* и *Phoma macdonaldii*	1111 A x 485 R 1111 A x 473 R	1111 A x 488 R 1111 A x 524 R

CONCLUSIONS

The results showed that the experimental hybrids were distinguished on their ecological plasticity. The lowest susceptibility to different climatic conditions were established for the hybrids 1111A x 3060 R and 1111A x 185 R. These hybrids were characterized with resistance to downy mildew and broomrape, high seed oil content and oil yield respectively. They were submitted to continue the official variety testing.

REFERENCES

Al-Khatib, K., J.R. Baumgartner, D.E. Peterson, R.S. Currie, 1998. Imazethapyr resistance in common sunflower (*Helianthus annuus*). Weed Science 46: 403–407.

Al-Khatib, K., J.F. Miller, 2000. Registration of four genetic stocks of sunflower resistant to imidazolinone herbicides. Crop Science 40: 869–870.

Barov, V. J. Shanin, 1965. Methodology of field experiments. Sofia.

Bruniard, J.M., J.F. Miller. 2001. Inheritance of imidazolinone herbicide resistance in sunflower. Helia 24: 11–16.

Evci, G., V. Pekcan, M. I. Yılmaz, Y. Kaya, 2012. The Resistance breeding to IMI and SU herbicides in sunflower. Plant Science 49, 6-11.

Kaya, Y., 2014. Sunflower. A. Pratap. (Ed) Alien Gene Transfer in Crop Plants, Vol. 2. Springer Press. 281-315.

Kaya, Y., G. Evci, V. Pekcan, I. M. Yilmaz, 2013. Clearfield Technology in Sunflower and Developing Herbicide Resistance Sunflower Hybrids. Soil-Water Journal. 2(2): 1713-1720.

Sala, C. A., M. Bulos, A. M. Echarte, S. Whitt, G. Budziszewski, W. Howie, B. Singh, B. Weston, 2008a. Development of CLHA-Plus: a novel herbicide tolerance trait in sunflower conferring superior imidazolinone tolerance and ease of breeding. In: Proc. XVII Int. Sunflower Conf., Cordoba, Spain, pp. 489–494.

Sala, C.A., M. Bulos, A. M. Echarte, 2008b. Genetic analysis of an induced mutation conferring imidazolinone resistance in sunflower. Crop Science 48:1817-1822.

Sala, C.A., M. Bulos, E. Altieri, M. L. Ramos, 2012. IMISUN tolerance is the result of theinteraction between target and non-target tolerance mechanisms. In: Proc. 18th Sunflower Conf., Mar del Plata-Balcarce, Argentina, pp. 551-556.

Skoric, D., 2012. Sunflower breeding. In: Skoric, D. (editor), Sunflower genetics and breeding. Serbian Academy of Sciences and Arts, Novi Sad, Serbia, pp. 165-354.

Tan, S., R. R. Evans, M. L. Dahmer, B. K. Singh, D. L. Shaner, 2005. Imidazolinone-tolerant crops: history, currentstatusandfuture. Pest Management Sci. 61(3):246-57.