PROCEEDINGS OF THE

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The proceedings or the 20th International Sunflower Conference contain 153 contributions from scientists of 30 countries. They include plenary lectures, oral talks and regular communications presented with posters, among which, selected contributions were emphasized with short oral talks. The manuscripts are classified by research areas in ten separate sections. They offer a thorough review of the current state of the art of sunflower research and production around the world. The Organizing Committee is grateful to Tanja Vunjak and Aleksandar Vojisavljević for their excellent editorial assistance in the preparation of these Proceedings.

ISC2022 Organizing committee

Conference program

Sunday, 19 June

16.00-21.00	Registration
19.00-21.00	Welcome Reception

Monday, 20 June

8.00-17.00	Registration	
9.00-9.30	Opening Ceremony	
9.30- 10.15	**Invited talk** Section 1: Dr. Felicity Vear (France)	
10.15-11.00	Coffee break	
11.00-12.00	**Section 1:** *Breeding – New/old breeding goals and challenges*	**Section 2:** *Oils and proteins - Innovations for increased quality and feedstock supply*
	Oral and short oral presentations	**Oral and short oral presentations**
12.00-13.30	Lunch	
13.30-14.30	**Invited talks** Section 3: Dr. C.C. Jan (China) Section 4: Dr. Sreten Terzić (IFVCNS, Serbia)	
14.30-15.00	Coffee break	
15.00-16.00	**Section 3:** *Confectionery sunflower – Emerging crop*	**Section 4:** *Genetic resources – Investment for the future*
	Oral and short oral presentations	**Oral and short oral presentations**
16.00-17.00	**Poster session** – Sections 1, 2, 3, 4	
18.00-21.00	Novi Sad and Petrovaradin fortress tour	

Tuesday, 21 June

8.30-17.00	Registration	
9.30-10.30	**Invited talks** Section 5: Dr. Leire Molinero Ruiz (CISC, Spain) Section 6: Dr. Philippe Debaeke (INRAE, France)	
10.30-11.00	Coffee break	
11.00-12.00	**Section 5:** *Biotic stress resistance – New and emerging pests and diseases*	**Section 6:** *Crop production and modeling – Yield stability in changing environment*
	Oral and short oral presentations	**Oral and short oral presentations**
12.00-13.30	Lunch	
13.30-14.30	**Invited talks** Section 7: Dr. Nicolas Langlade (INRAE, France) Section 8: Etienne Pilorgé (Terres Inovia, France)	
14.30-15.00	Coffee break	
15.00-16.00	**Section 7:** *Abiotic stress resistance – Challenges of changing environment*	**Section 8:** *Economy and market – Trends and prospects*
	Oral and short oral presentations	**Oral and short oral presentations**
16.00-17.00	**Poster session** – Sections 5, 6, 7, 8	

Wednesday, 22 June

8.30-17.00	Registration	
9.30-10.30	**Invited talks** Section 9: Dr. Stéphane Muños (INRAE, France) Section 10: Dr. Nicole Creux (FABI, South Africa)	
10.30-11.00	Coffee break	
11.00-12.00	**Section 9:** Broomrape – *Constant challenge*	**Section 10:** *Bees and seeds – Exploring new venues for increased yield and seed production*
	Oral and short oral presentations	**Oral and short oral presentations**
12.00-13.30	Lunch	
13.30-14.30	**Panel:** *Sunflower in a changing environment – Trends and prospects*	
14.30-15.00	Coffee break	
14.30-15.30	**Poster session** – Sections 9, 10	
15.00-16.30	ISA Assembly	
16.30-17.00	Closing ceremony	
20.00-24.00	Gala Dinner Pustavoit Award Presentation Ceremony IFVCNS Best Poster Award Presentation	

Thursday, 23 June

9.00-15.00	Field day

Table of contents

SHORT ORAL TALKS

SEED SIZE AND SUBSTRATE EFFECT ON SEED GERMINATION OF INBRED SUNFLOWER LINES

Miloš Krstić[1*], Jelena Ovuka[1], Velimir Radić[1], Sonja Gvozdenac[1], Vladimir Miklič[1], Velimir Mladenov[2], Borislav Banjac[2], Teodora Kukrić[2]

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Abstract

Agricultural production especially seed production, is highly important due to the fact that 95% of food is produced from plants that reproduce with seeds. For successful seed production, it is necessary to use certified seed with high germination. Seed size is one of the components of seed quality, which has a high effect on seed germination. The aim of this research was to determine the influence of seed size, obtained during seed processing, originating from the same location, on the germination of seeds of sunflower inbred lines and to assess the influence of substrate on seed germination. The study included larger and smaller seed size fractions of nine inbred lines of sunflower on three different substrates (filter paper, sand and soil substrate). The seed material for this research was produced in Serbia and Bosnia and Herzegovina. The results indicate that germination depended on the seed size, but also statistical analysis determined highly significant influence of substrate and genotype and their interaction. It was also found that larger seeds achieved a higher germination rate by 2% than smaller seeds, regardless the substrate and inbred line, and the difference was statistically significant. Therefore, it is recommended to sow larger seeds and achieve better seed germination which directly affects the number of plants per unit area.

Keywords: inbred lines, germination, substrate, sunflower, seed size

Introduction

Two largest producers provide more than 50% of sunflower oil in the world are Ukraine (28%) and Russia (25%) (FAO, 2021). These countries, along with the European Union and Argentina, occupy 76% of global sunflower production (Jocić et al., 2015). In Serbia, sunflower is the main oily plant species, with over 80% of the total quantity produced from all oils of plant origin (Ćuk et al., 2020). Its high drought tolerance and adaptation to a great variety of soils, the sunflower is suitable for cultivation in many regions of the world and is been spreading to many countries including Asia and Africa (Jocić et al., 2015). Forecasts of human population growth and climate change lead to the conclusion that the current sunflower production are not sufficient to meet future needs (Radanović et al., 2018). Agricultural production, especially seed production, is extremely important because 95% of the food is produced from plants that reproduce with seeds. It is thought that global climate change will leave a significant impact on seed germination in most plant species (Huang et al., 2017). Seed quality is key to increasing sunflower production and productivity (Lima et al., 2014). Rapid germination of plants is an important precondition for successful seed production in systems without irrigation. The size of the seed plays an important role in the germination (Nerson, 2002; Semerci, 2013; Ovuka et al., 2016) and the formation more

lush seedlings, which is necessary for achieving the optimal number of plants per unit area, directly impact seed yield (Nik et al., 2011). Seed germination depends on a multitude of endogenous and exogenous factors such as temperature, light, soil humidity (Toscano et al., 2017; Varga et al., 2020; Vicente et al., 2020). In addition to seed processing after the harvest (Miklič et al., 2012; Fattahi et al., 2017), the influence of agoecological factors during vegetation on seed germination is much greater than the influence of the genotype itself (Lachabrouilli et al., 2021). One of the necessary conditions for achieving high yields is the use of certified, high-quality seeds of larger size (Ahmad et al., 2001; Galindez et al., 2009). Many authors believe that in addition to water and the duration of the photoperiod, temperature, a very important factor that affects the germination of seeds is the substrate (Santos et al., 2018).

The methodology for germination testing has been standardized by ISTA (International Seed Testing Association) providing results that can be compared between accredited laboratories (Milošević and Kobiljski, 2011). The aim of this research was to determine the effect of size of seeds (different fractions obtained during seed processing), originating from the same site on germination of sunflower inbred lines and to evaluate the influence of the substrate on seed germination.

Materials and Methods

Sunflower inbred lines used in this work originate from the Institute of Filed and Vegetable Crops in Novi Sad. Tests were performed according to ISTA Rules, using larger and smaller size seeds of nine sunflower inbred lines (Table 1). The seed material for this research was multiplied in Serbia and Bosnia and Herzegovina. On the agreed seed plots all agrotechnical measures required by the production technology of the basic seed of sunflower have been applied.

Table 1. Inbred lines of sunflower

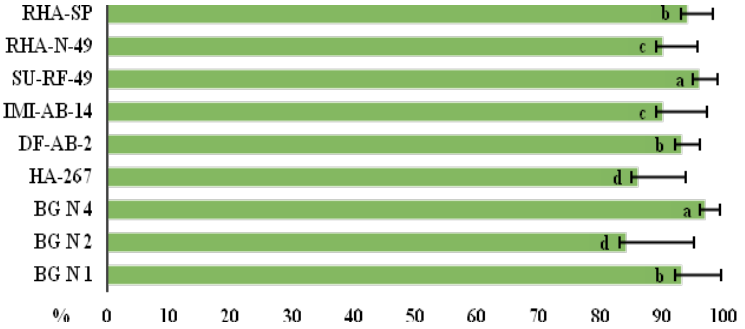
G	BG N 1	BG N 2	BG N 4	DF-AB-2	HA-267	IMI-AB-14	RH-SP	SU-RF-49	RHA-N-49
Plh	cms-line-female component						Rf-line-male component		
Ss	I-3,75 mm; II-3,00 mm						I-2,50 mm; II-2,25 mm		

G-genotype; Plh-parental lines of hybrids; Ss-seed size; I-larger size seeds; II- larger size seeds

After harvesting and primary seed processing, seeds were separated by size on the processing line, starting from fine purifier, trier, and fractionator to gravity table. On the fractionator, with the help of slotted sieves of different sizes, larger and smaller seed size fractions were separated. The lower sieve for the larger size is 3.75 mm for the cms-line, while for the restaurant it is 2.50 mm. The lower sieve for the smaller seed size is 3.00 mm for the cms-line, while for the restaurant 2.25 mm. The seed purity of all inbred lines was 99.9%. Three months after the processing, and passing dormancy naturally, the seeds were subjected to standard germination test. Test included four replicates of 100 seeds per replicate, on different substrates for seed germination (filter paper, sand and soil substrate) and temperature. Seed incubation duration is stipulated by the Rule on seed quality testing of agricultural plants (1987) and the ISTA Rules (2018). On all three substrates, the final germination of seed was recorded after 10 days. The results were processed statistically in the SPSS program using: basic descriptive statistics and three factor analysis of variance (ANOVA) using Duncan's multiple interval test.

Results and Discussion

Using the standard laboratory test, the germination of seeds of larger and smaller size of nine inbred lines of sunflower, on three different substrates was determined. On average, the highest germination for all examined substrates was achieved by cms-line BG N 4 (97%), and the lowest cms-line BG N 2 (84%) (Picture 1). The average value of seed germination of larger size seeds of all inbred lines was statistically significantly higher by 3% on filter paper and 2% in soil substrate, compared to the smaller size seeds, while in sand the smaller size seeds achieved higher germination by 1% (Picture 2).



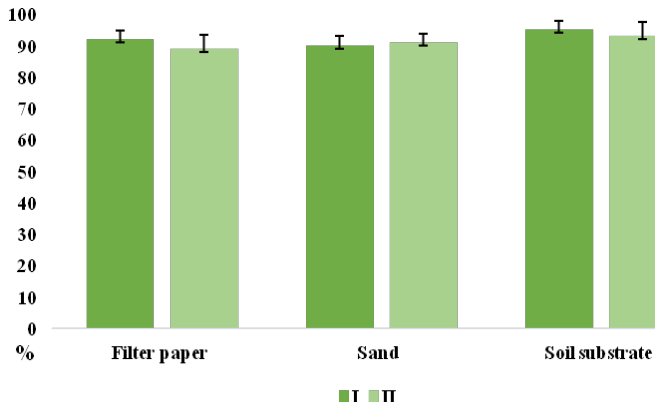
Picture 1. Seed germination of tested inbred lines

On average, on all substrates for all tested inbred lines of sunflower, the larger size seeds achieved 2% higher seed germination than the smaller size seeds (Table 2). In the case of cms-line, the seeds of smaller sizes achieved 1% higher seed germination than the larger one, while in the restorer line, the seeds of larger sizes achieved 2% higher germination compared to the smaller one. Germination of seeds ranged from 100% in the case of smaller size seeds (cms-line BG N 4) to 67% achieved by the smaller size seed cms-line BG N 2.

In the soil substrate, the highest value was achieved for cms-line BG N 1 (98%), regardless of the seed size, and the lowest value of seed germination was achieved for smaller size seeds of cms-line IMI-AB-14 (82%).

The highest germination of smaller size seeds in the sand was achieved by the seeds of cms-line BG N 4 (100%), while the lowest value for large seeds was recorded for cms-line HA-267 (74%).

In filter paper, the highest germination of large seeds was achieved by restorer line SU-RF-49 (99%), while for the smaller size seeds the highest was of BG N 2 (67%). On average, in all inbred lines, the highest germination was recorded when on the soil substrate, for larger size seeds it was 95%, and for the smaller size seeds it reached 93%.



Picture 2. Germination of larger and smaller size seeds of tested inbred lines on different substrates I-larger size seeds; II-smaller size seeds

Table 2. Seed germination of inbred sunflower lines tested on different substrates

Genotype	Filter paper %			Sand %			Soil substrate %		
	I	II	A±SD	I	II	A±SD	I	II	A±SD
BG N 1	95	96	96±2,67^{ab}	83	89	86±6,11^{d}	98	98	98±1,98^{a}
BG N 2	83	67	75±11,72^{f}	80	82	81±2,39^{e}	96	94	95±3,55^{ab}
BG N 4	97	96	97±1,88^{ab}	99	100	100±1,25^{a}	97	97	97±2,60^{ab}
HA-267	86	84	85±4,27^{e}	74	85	80±7,74^{e}	92	93	93±4,50^{bcd}
DF-AB-2	92	93	93±2,76^{bc}	92	94	93±2,55^{c}	95	93	94±4,06^{abc}
IMI-AB-14	94	95	95±3,92^{ab}	90	82	86±5,13^{d}	96	82	89±9,19^{d}
SU-RF-49	99	98	99±1,06^{a}	97	93	95±3,25^{bc}	96	95	96±2,31^{ab}
RHA-N-49	90	82	86±4,70^{de}	94	95	95±2,91^{bc}	91	90	91±5,70^{cd}
RHA-SP	91	89	90±2,80^{cd}	98	97	98±0,52^{ab}	95	94	95±3,77^{abc}
Average	92	89	90	90	91	90	95	93	94
Min	83	67	75	74	82	80	91	82	89
Max	99	98	99	99	100	100	98	98	98

I-larger size seed; II-smaller size seed; A-average; SD-standard deviation

The results of the tree factor ANOVA (Table 3) showed a statistically highly significant influence of genotype and substrate, as well as their interaction and a statistically significant influence of seed size on the variation of seed germination. It is evident that seed size affects seed germination and thus that the differences that occurred between genotypes were due to different seed sizes of restorers and cms-lines. Ahmed et al. (2019) state that the physical parameters of seeds have a high impact on the germination of sunflower seeds. The genetic constitution of a genotype causes variability in seed size between genotypes. This variation is a consequence of the flow of nutrients in the parent plant, plants that germinate from larger seeds achieve the most germination and higher seed yields (Ambika et al., 2014). Germination of hybrid seeds can be influenced by the effects of the maternal line, as well as the genetic constitution of the seed embryo, which are the result of the contribution of both parents (Weiss et al., 2013). Nasreen et al (2015) state that there are statistically highly significant differences between genotypes in terms of seed germination of sunflower hybrids, which is in agreement with these results.

Table 3. The influence of all three factors on seed germination of tested inbred lines

Source	df	F	p
Fraction	1	6.34*	0,013
Genotype	8	32,63**	0,000
Substrate	2	20,75**	0,000
Fraction x Genotype	8	4,24**	0,000
Fraction x Substrate	2	5,36**	0,006
Genotype x Substrate	16	13,84**	0,000
Fraction x Genotype x Substrate	16	3,03**	0,000

p<0,05*: statistic significant difference; p<0,01**: statistic high significant difference

Mrđa (2015) stated that the seeds of larger size achieved highest germination, that confirms the already been proven fact that the seed size affects the germination. In their work, Liović et al. (2006) stated that the highest germination was achieved on average by smaller size seeds

of restorers, which is not in accordance with the results of this research, where the larger size seeds of restorers achieved on average 2% higher value of seed germination. Krishnaveni et al. (2001) stated that medium and larger sizes of seeds achieved 8% higher germination compared to smaller one, and also pointed out that the genotype itself influenced the realization of statistically highly significant differences. The value of energy and germination of seed increased with increasing seed size, according to Roy et al. (1996). Sunflower plants originating from seeds with seed size above # 3.0 mm achieved a higher plant height, number of leaves, stem circumference and germination of the produced seed, Nagaraju et al. (2001). Ahmed et al. (2019) also reported the size of sown seeds had a significant effect on germination of seed, plant height, number of leaves, leaf surface. The same authors pointed out that larger sunflower seeds in all sowing depths achieved higher seed germination than smaller seeds. Mishra et al. (2008) concluded that the use of larger seeds is much better in terms of field germination and plant performance than the use of medium-sized seeds, for this reason they recommend avoiding the use of smaller seeds. Contrary to these allegations, Saranga et al. (1998) and Farahani et al. (2011) reported that smaller seeds of sunflower achieved the highest value of seed germination and dry weight of sprouts. Singh et al. (2021) stated a significant influence of the substrate for germination on seed germination, while da Silva et al. (2017) pointed out the opposite. The same authors pointed out that the soil substrate achieved on average 7% higher germination than sand, which is in accordance with this paper. The highest germination of seed was achieved on filter paper (95%), while the lowest on sand (80%) was stated by Mrđa et al. (2010). Yerima et al. (2015) pointed out that increasing the amount of soil in the substrate leads to an increase in seed germination and that on average the highest seed germination was achieved in the substrate, which is in accordance with the results of this research.

Conclusions

Based on the results obtained in this study, it can be concluded that the process of seed processing, i.e. separation of seeds by sizes affects seed germination. Also, in addition to seed size, the substrate for germination of seed, the genotype itself and their interactions have a high statistically significant influence on seed germination. It was also found that on average on all seed germination substrate, in all tested inbred sunflower lines, larger seeds achieve higher germination by 2% than smaller ones, which is statistically significant. Therefore, it is recommended to sowing larger seeds, in order to achieve better seed germination that directly affects to the number of plants per unit area.

Acknowledgements

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