UDC 575.630
https://doi.org/10.2298/GENSR2003911C
Original scientific article

VARIABILITY OF MORPHOLOGICAL TRAITS IN SUNFLOWER INBRED LINES

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Ćuk N., S. Cvejić, V. Mladenov, B. Babec, V. Miklič, D. Miladinović, S. Jocić (2020). *Variability of morphological traits in sunflower inbred lines* - Genetika, Vol 52, No.3, 911-923.

Except agronomic important traits, great diversity in sunflower is present in morphological traits which are very useful in breeding studies. The main objective of the paper was to determine genetic diversity among the 110 inbred lines in the collection of Institute of Field and Vegetable Crops Novi Sad (IFVCNS) by screening 34 morphological traits according to a list of descriptors of the International Union for the Protection of New Varieties of Plants (UPOV) as to conduct the Distinctness, Uniformity and Stability Test (DUS). The diversity of morphological traits was estimated by *Shannon* diversity index (*H'*) and the diversity of sunflower inbred lines was performed by homogeneity analysis (HOMALS) as well as discriminatory power of the traits. The values of the traits in *Shannon* diversity index were the highest (*H'*=0.99) for height of the tip of the blade compared to insertion of petiole and bract position, while branching, head shape and seed color showed low diversity (*H'*>0.1). The uniformity of inbred lines distribution determined discriminative power of descriptors. Disk flower anthocyanin coloration of stigma, hypocotyl anthocyanin coloration and intensity, leaf blistering, leaf serration, seed stripes on and between the margins showed the strongest discriminatory power. According to these six traits, the collection of inbred lines was divided into two main groups and three subgroups which better explained the relationships among the various inbred lines. Inbred lines showed the great variability of morphological traits in the whole collection and also among the inbred lines from the same type of use.

Keywords: genetic diversity, inbred lines, sunflower, morphological traits

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INTRODUCTION

Sunflower (*Helianthus annuus* L.) hybrids are used in commercial production and produced by cross-pollinating the female line, which is a cytoplasmatic male sterile, with the male line, which has a fertility restoration gene. The advantages of hybrid over the open-pollinated varieties are higher yields, uniformity, increased self-fertility, and resistance to major diseases (JOCIĆ *et al.*, 2015). By crossing two genetically divergent inbred lines, the subsequent progeny has better morphological and agronomic traits than both parents i.e., heterosis occurs. Utilization of genetic distance between inbred lines for predicting hybrid heterosis has been of great interest to breeders. The efficiency of hybrid breeding programs is higher if there is great variability among inbred lines.

Except agronomic important traits, great diversity is present in morphological traits as well, which can be useful in breeding studies (LIMA *et al.*, 2017). Diversity of these traits is used in the process of creating and registration of new varieties where it is necessary to evaluate them by Distinctness, Uniformity and Stability (DUS) testing (ANGADI and JAGADEESHA, 2018). Evaluation of morphological traits is less affected by environmental than agronomic, and they are mostly monogenic (BHANDARI *et al.*, 2017). Diversity among morphological traits can influence on heterosis and be reliable marker for prediction hybrid potential. The genus sunflower has a very high variability, in wild ecotypes as well in breeding genotypes (RADANOVIĆ *et al.*, 2018). Sunflower genotypes differ in plant architecture, types of branching, flower colour and morphology, number and size of heads, seed size and colour and many other traits (CVEJIĆ *et al.*, 2016).

Sunflower breeding at the Institute of Field and Vegetable Crops in Novi Sad (IFVCNS), Serbia, has a successful 50-year long tradition. The result of the breeding program is a collection of over 7000 IFVCNS inbred lines mostly developed for hybrid production (JOCIĆ *et al*., 2012). Collection of inbred lines was created by breeding work on the material introduced from other countries, exchanging material with other institutes, and interspecies hybridization with wild species. The main objective of this work was to determine the genetic diversity among elite inbred lines maintained in the collection of IFVCNS. The aim of this work was to determine the degree of diversity of morphological traits, analyze discriminatory powers of the qualitative traits of the studied material, determine whether certain groups of inbred lines are distinguished on the basis of traits with high discriminatory power, and inspect the connection between variability of inbred lines their purpose of use.

MATERIAL AND METHODS

Collection of 110 elite sunflower inbred lines was used for genetic variability study. Represented inbred lines have different types of use. The largest group are conventional inbred lines with high oil content (75), high oleic (HO) inbred lines (11), tolerant to imidazolinone herbicide, Clearfield (IMI) and Clearfield Plus (CLP) technology (17), tolerant to sulphonyl-urea (SU) herbicide (6), ornamental lines (2) and for bird feed (1). In Table 1 are shown all used sunflower inbred lines per types of use. Inbred line No. 10 is HO and CLP, while inbred line No. 13 is HO and SU.

Table 1. List of the 110 used sunflower inbred lines and type

Type of inbred lines	Number of inbred lines
Conventional	1, 2, 3, 4, 5, 6, 7, 14, 15, 16, 17, 19, 20, 22, 24, 26, 29, 30, 31, 32, 34, 35, 40, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 101, 102, 103, 104, 105, 106, 107, 108, 109
High oleic (HO)	10, 12, 13, 36, 37, 38, 39, 68, 69, 70, 100
Clearfield (IMI)	6, 7, 29, 30, 31, 32
Resistant to sulphonil urea (SU)	13,14,15,35, 40, 100
Clearfield Plus (CLP)	8, 9, 10, 11, 18, 21, 23, 25, 27, 28, 41
Ornamental	67, 110
For bird feed	33

Experimental trial was established at the Institute of Field of Institute of Field and Crops in Novi Sad during a three year period (2016–2018). The experimental trial was set up as a randomized block design with three repetitions, using ten plants per repetitions in the sample size. The space was 0.7 m between rows and 0.25 min the rows.

All traits were measured for all inbred lines according to Phenotypic Guidelines of the International Union for Protection of New Varieties of Plants - UPOV (UPOV, 2000). Although UPOV guidelines have 42 traits, we evaluated 34 morphological traits used for Distinctness, Uniformity and Stability (DUS) test. Due to easier data manipulation, some traits have been brought together during the evaluation of hypocotyl anthocyanin coloration and hypocotyl anthocyanin coloration intensity, disk flower anthocyanin coloration of stigma and disk flower anthocyanin coloration of stigma intensity. Plant branching was presented as a grade in the plant branching type and plant natural position of the highest lateral head. All inbred lines were unique in pollen production and seed spots on pericarp, so these traits were not use in analyses. An evaluation of each phenotypic trait has been made visually on field, except the seed traits which were evaluated in the laboratory after harvesting and sampling.

Evaluation was conducted in several vegetation phases:

- field emergence: hypocotyl (intensity of anthocyanin coloration)
- bud phase: leaf (size, green color, blistering, serration, shape of cross section, shape of distal part, auricles, wings, angle of lowest lateral veins, height of the tip of the blade compared to insertion of petiole),
- flowering: stem (hairiness at the top), ray flowers (density, shape, disposition, length, color), disc flowers (color, anthocyanin coloration of stigma) and bracts (shape, length of tip, green color of outer side),
- physiological maturity: head (attitude, shape of grain side) and plant branching (type of branching, natural position of highest lateral head to central head) and
- after harvesting: seed (size, shape, thickness relative to width, main color, stripes on margins, stripes between margins).

The data were analyzed by *Shannon* index of diversity (*H’*). This index is reliable diversity indicator for variability of the examined traits which considered that heterogeneity population depends of the number of specific genotypes in a population and their proportional ampleness. Results provided by diversity index have values between 0 and 1 (PLA *et al.*, 2011). High value of this index is an indicator of good homogeneity of the trait in the tested collection, while the low value is a sign of the unbalanced diversity of certain trait (SARMA and DAS, 2015). Data were thereafter analyzed with the Homogeneity Analysis (HOMALS) which claims that the observed categorical variables have a Euclidean representation in a latent (unobserved) Euclidean space (SAMBASIVAN and DAS, 2016). The HOMALS analysis is similar to Principal component analysis (PCA), but it was used for nominal data, and also this analysis gives better graphical represented data (PERIĆ, 2015). It represented which traits will better describe inbred lines (discriminatory power) and have practical breeding importance, particularly in the context of selection (FERRANDO, 2012). HOMALS analyze represented discriminatory powers of all examined traits and selected the traits with the strongest discriminatory powers. HOMALS analysis illustrated genetic distance between inbred lines within the collection, and ability of traits to describe the inbred lines (MORRIS *et al*., 2014; RADINOVIĆ, 2018).

RESULTS AND DISCUSSION

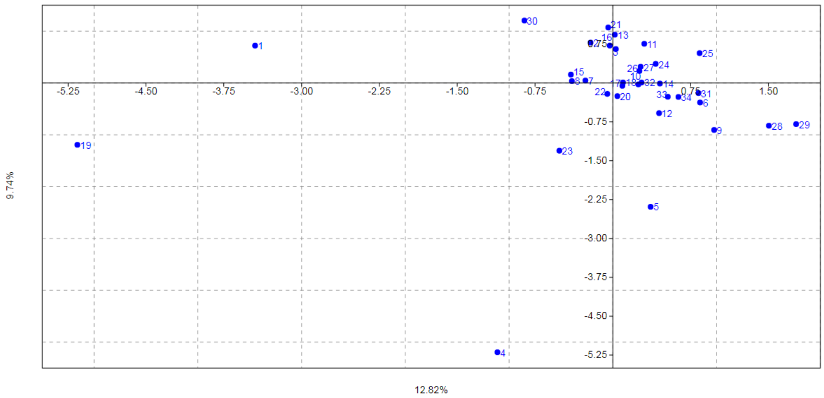
Shannon index is very reliable diversity indicator for variability of the examined trait. The values of the traits in *Shannon* diversity index are represented in Table 2. Traits with high values of *Shannon* diversity index (*H'*>0.9) were hypocotyl anthocyanin coloration, leaf color, leaf angle of the lowest veins, leaf height of the tip of the blade, ray floret density, bract position and stripes on and between margins. Higher values of *H'* index revealed even distributions of inbred lines within the phenotypic classes (MORENO *et al*., 2013; HLADNI *et al*., 2017). Moreover, traits such as leaf height of the tip of the blade and bract position had the highest *Shannon* index (*H'*=0.99). These two traits also had a large impact on seed yield, so it was probably the reason for their variability within the collection (SRIVASTAVA *et al.*, 1977). Low diversity traits with *H'*>0.1, were plant natural position of highest lateral head, head shape, seed color and plant type of branching and the whole collection were almost uniform by these traits. Low *H'* index indicated an extremely unbalanced distribution for these traits and a lack of diversity. Most of the sunflower inbred lines today on the market are non-brunched and with black seed (SEILER and GULYA, 2015).

Table 2. List of the examined traits, marks and number of inbred lines with marks and H' values

Trait	Marks and Number of genotypes	*H'*
Hypocotyl: anthocyanin coloration	absent (12), weak (45), medium(22), strong (31)	0,93
Leaf size	small (35), medium (62), large (13)	0,86
Leaf color	light (29), medium(59), dark (22)	0,92
Leaf blistering	absent (55), weak (39), medium (16)	0,62
Leaf serration	isolated (12), fine (50), medium (39), coarse (8), very coarse (1)	0,75
Leaf: shape of cross section	strongly concave (9) weakly concave (51) flat (41) weakly convex (9)	0,7
Leaf: shape of distal part	narrow triangular (27), broad triangular (5), broad triangular to rounded (16), rounded (8)	0,6
Leaf auricules	small (8), medium (36), large (60) very large (6)	0,55
Leaf wings	very weakly expressed (66), weakly expressed (34), strongly expressed (10)	0,81

Leaf: angle of lowest veins	acute (36), right, nearly right angle (55), obtuse (19)	0,92
Leaf: height of the tip	low (31), medium (46), high (33)	0,99
Steam hairiness	absence (1), weak (25), medium (52), strong (26), very strong (6)	0,67
Ray florets: density	sparse (26), medium (51), dence (33)	0,96
Ray floret: shape	fusiform (18), narrow ovate (81), broad ovate (10), rounded (1)	0,56
Ray floret: disposition	flat (81), longitudinal recurved (10), undulated (11), strongly recurved to back of head (8)	0,62
Ray floret: length	short (17), medium (73), long (20)	0,79
Ray floret: color	medium yellow (29), orange yellow (76), orange (5)	0,36
Disc floret color	yellow (10), orange (92), p (2)	0,36
Disk flower: anthocyanin stigma coloration	absence (88), weak (14), medium (7), strong (1)	0,47
Bract shape	clearly elongated (11), neither clearly elongated nor clearly rounded (56) rounded (43)	0,86
Bract: length of tip	very short (1), short (14), medium (5), long (7), very long (2)	0,64
Bract: green color of outer side	light (24), medium(74), dark (12)	0,76
Bract: attitude in relation to head	not embracing or very slightly embracing (40), slightly embracing (41), strongly embracing (29)	0,99
Plant: type of branching	Absent(108), predominantly apical (2)	0,01
Plant: natural position of highest lateral head	absent (108) Below (1), same level (1)	0,07
Head: attitude	inclined (2), vertical (30), half-turned down with straight stem (31), half-turned down with curved stem(18), turned down with straight stem (3), turned down with slightly curved stem (15), turned down with strongly curved stem (11)	0,46
Head: shape	weakly concave (3), flat (59), weakly convex (30), strongly convex (15), deformed (3)	0,05
Seed: stripes on margin	none or weakly expressed (26), weakly expressed (45), strongly expressed (39)	0,98
Seed: stripes between margin	none or weakly expressed (44), weakly expressed (48), strongly expressed (18)	0,93
Seed: color of stripes	without stripes (21), White (7), gray (66), brown (14), black (2),	0,51
Seed thickness	thin (18), medium (80), thick (12)	0,70
Seed color	white (1), gray (5), light brown (1), medium brown (8), black (95)	0,07
Seed size	small (1), medium (39), large (68), very large (2)	0,48
Seed shape	elongated (4), narrow ovoid (14), board ovoid (78), rounded (14)	0,46

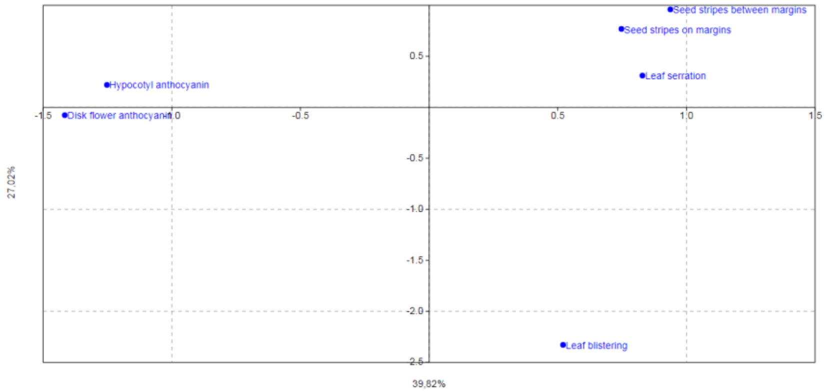
Discriminatory power of the examined 34 morphological traits was obtained by the HOMALS analysis (Graphic 1). The highest distance between zero value of the both axes and some traits mean higher discriminatory power of that trait, while lower distance mean lower discriminatory power. On the graphic horizontal axis explained 12.82% of discriminatory power while vertical axis explained 9.74%. Six traits were determined to have the highest discriminatory power: disk flower anthocyanin coloration of stigma, hypocotyl anthocyanin coloration and intensity, leaf blistering, leaf serration, seed stripes on margin and seed stripes between margins. Similar results were noticed in literatures, where great variability is showed among the cultivated sunflower and *Helianthus* relatives (TAN *et al.*, 2013; PURWATI and HERWATI, 2016).



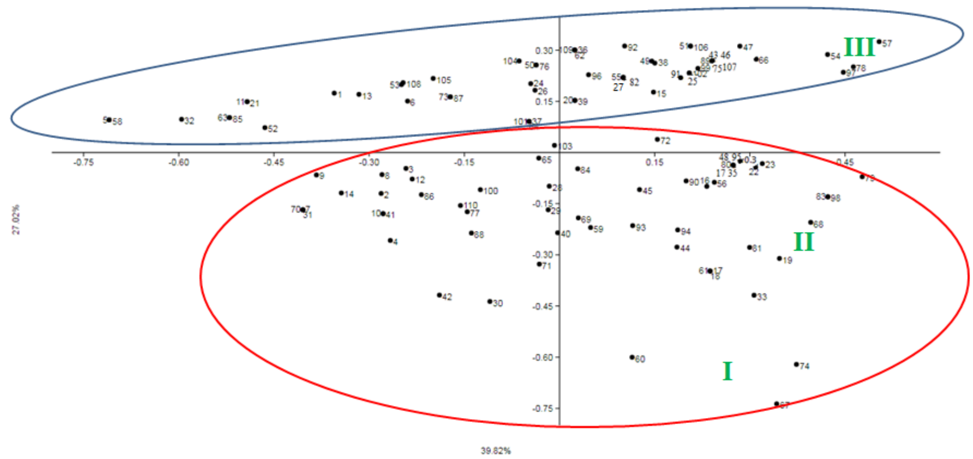
Graphic 1. Homals analysis showing traits with their discriminatory power.

1-Hypocotyl anthocyanin coloration and intensity; 2-leaf size, 3-leaf green color, 4-leaf blistering, 5-leaf serration, 6 – leaf shape of cross section, 7 – leaf shape of distal part, 8 – leaf auricules, 9 – leaf wings, 10 -Leaf: angle of lowest lateral veins, 11- Leaf: height of the tip of the blade, 12 - Stem: hairiness, 13 - Ray florets: density, 14 - Ray floret: shape, 15 - Ray floret: disposition 16 - Ray floret: length, 17 - Ray floret: color, 18 - Disk flower: color, 19 - Disk flower: anthocyanin coloration of stigma, 20 - Bract: shape, 21 Bract: length of tip 22 - Bract: green color 23 - Bract: attitude in relation to head 24 – Plant branching and type of brunching, 25 - natural position of highest lateral head to the central head 26 - Head: attitude 27 Head: shape of grain side 28 Seed stripes on margin 29 Seed stripes between margins , 30 Seed: main color, 31 Seed: color of stripes, 32 Seed: size 33 Seed: shape 34 Seed: thickness

Further analyses involved only traits with the highest discriminatory power (Graphic 2) which explained 66.84% of total variability. Selected traits were distributed similar as in Graphic 1.



Graphic 2. The discriminatory power of six traits that are used for HOMALS analyses of inbred lines.



Graphic 3. Homals analysis of sunflower inbred lines based on six traits with strong discriminatory power. Blue circle consider inbred lines which did not have leaf blistering, while red circle consider inbred lines with different levels of leaf blistering. Roman numbers are marked three small subgroups of inbred lines.

The 110 inbred lines were distributed according to six morphological traits with the highest discriminatory power (Graphic 3). Inbred lines were physically divided into two large groups. The first group was marked with upper circle (blue), and it consisted of 55 inbred lines which did not exhibit the signs of leaf blistering (1, 5, 6, 11, 13, 15, 20, 21, 24, 25, 26, 27, 32, 34, 36, 37, 38, 39, 43, 46, 47, 49, 50, 51, 52, 53, 54, 55, 57, 58, 62, 63, 64, 66, 73, 75, 76, 78, 82, 85, 87, 89, 91, 92, 96, 97, 99, 101, 102, 104, 105, 106, 107, 108, 109), while in the second group (red circle) 55 inbred lines had different levels of leaf blistering and were marked with lower circle (2, 3, 4, 7, 8, 9, 10, 12, 14, 16, 17, 18, 19, 22, 23, 28, 29, 30, 31, 33, 35, 40, 41, 42, 44, 45, 48, 51, 56, 59, 60, 61, 65, 67, 68, 69, 70, 71, 72, 74, 77, 79, 80, 81, 83, 84, 86, 88, 90, 93, 94, 95, 98, 100, 103, 110).

Within the main groups, it was possible to identify three subgroups of inbred lines that had specific trait performance (Graphic 3, marked with roman letters). The first subgroup included inbred lines with numbers 60, 67 and 74. These three inbred lines were the only ones in the collection that have a combination of medium leaf blistering, fine leaf serration, no anthocyanin coloration of stigma of disc flowers and no stripes between margins. The second subgroup involved inbred lines 19, 33, 68, 79, 83, 98 that did not have anthocyanin coloration on hypocotyl, stigma of disc flowers and had weak leaf blistering. The third subgroup includes inbred lines 54, 57, 78, 97 that did not show anthocyanin coloration on the hypocotyl, stigma of disc flowers or leaf blistering.

Inbred lines with numbers 43, 46, 75, 89 and 107 had the same marks for the six high discriminatory power traits: weak anthocyanin coloration on hypocotyl, no leaf blistering, medium leaf serration, no anthocyanin of stigma of disc flowers, strongly expressed stripes on seed margin and weakly expressed stripes between seed margins. All of these five lines were overlapped in Graphic 3.

The HO inbred lines had weak or medium leaf serration and absence or weak anthocyanin of the stigma of the disc flowers. All HO lines, except line 68, had anthocyanin on hypocotyl, while only line 69 had medium leaf blistering. Other lines had weak or no leaf blistering, so these lines were at a small distance on the Graphic 3. The only trait that was the same for both ornamental inbred lines was medium leaf blistering, and because of that, these lines were not near each other. IMI inbred lines did not have stripes on seeds at all, but they all had anthocyanin on the hypocotil. Lines 7 and 31 had same all six high discriminatory traits. Similarity of SU inbred lines were the seed with stripes on the margins. All CLP lines also had seeds with stripes on the margins and anthocyanin on the hypocotil. HO and CLP inbred line 10, and HO and SU line 13 were different just in leaf blistering and stripes on the middle of the seed and showing great similarity. The only inbred line intended for bird feed, line 33, was in the separate group among the four conventional inbred and one HO line. Specific traits of inbred lines intended for different purposes are the presence of branching which frequently occurs in ornamental sunflower genotypes and white color of seed in the only inbred line intended for bird feed (LIN, 2005; MLADENOVIĆ *et al.,* 2017).

Size and shape of leaf could be indicator of the degree of the cognation with other species from the genus *Helianthus* or on mutation genes (POVERENE *et al.,* 2002; POVERENE and CANTTAMUTO, 2010; FAMBRINI *et al.,* 2010). The leaf traits could indirectly affect seed yield over the LAI-*leaf area index* (PAPATHEOHARI *et al.,* 2016). They were good in defining inbred lines, especially the height of the leaf top, which had the highest value of *Shannon* diversity index.

All traits of color and intensity color had low discriminatory power, like the color of ray and disc flowers and leaves. Inbred lines could not be defined by the disc flowers basic color, while anthocyanin presence gave the most accurate information about lines. Similar results were presented by CANTAMUTTO *et al.* (2010) who reported that American and Argentinean populations of sunflower did not show variability in the color of disc flowers. According to the results of HOMALS, traits such as anthocyanin coloration of hypocotyls and disc flowers had similar intensity, but this was not the case in the view of the *Shannon* index. The results were in accordance with SAYNAYARANA (2006) and HLADNI *et al.* (2017), who stated that the presence of anthocyanin on disc flowers is important for genotype determination. Anthocyanin on disc flowers could also be a sign of a relationship between the cultivated sunflower and other *Helianthus* relatives (POVERENE *et al.,* 2004). Basic color of the disc flowers in sunflower had low discriminatory power, which is in accordance with MLADENOVIĆ *et al.* (2016). According to TAN and TAN (2010), colors of the ray and disc flowers were the most divergent traits in sunflower, which was not in accordance with our study. It was assumed that researchers in this work evaluated presence of anthocyanin as a purple color. In the study of MLADENOVIĆ *et al*. (2017) a few genotypes with purple color were established, which indicates that it could be possible to obtain the desired color for different breeding goals, such as ornamental sunflower breeding.

Bract traits did not have high discriminatory power, but they had higher discriminatory power than color of ray flowers. Smaller bracts were an important trait in other species of the

Heliathus genus, and their absence can negatively affect yield (SRIVASTAVA *et al.,* 1977). Bract positions to the head were desirable because they can protect plants from bird damage (KHALEGHIZADEH, 2011; LINZ *et al.,* 2011). Only one line in this collection had small bracts. Bract traits also did not have high value of *Shannon* index, which was in accordance with SAYNAYARANA (2006), HLADNI *et al.* (2017).

Most of the sunflower hybrids were cultivated as non-branching, while sunflower wild relatives from the *Heliathus* genus exhibited dominant branching. Seed production of cultivated sunflower used branching genotypes, with the recessive gene as a male line in hybrid combinations. In branching male lines have longer time for flowering and provide better pollination (SEILER and JAN, 2014). In the whole collection, only the ornamental lines 67 and 110 had branches; the absence of the branches did not give reliable information of the genotype.

Head attitude and the shape were important traits for getting high yield so it was important that the position of the head has angle 135-180° and with concave to flat shape. It was possible to reach a high degree of protection from birds (KAYA, 2016). Head traits did not have strong discriminatory powers, so they did not describe lines precisely. The arrangement of different shapes in the collection was uneven, and because of that the value of *Shannon* diversity index was low. Similar distribution of these traits was noticed in literature (RAUF *et al.,* 2008; RAZZAQ *et al.,* 2014).

Seed traits with high discriminatory power were the intensity and color of the stripes. Other seed traits had low discriminatory power; color, shape and thickness of the seed. Basic color did not show strong effect on lines detection, but seed stripes gave them high diversity index values. HLADNI *et al.* (2017) reached similar conclusions where, contrary to the basic color, the color of seed stripes had high discriminatory power. High influence of the basic seed color had effect on the examined confectionary sunflower with often white or striped seeds, while oil seed sunflower usually had black seed color (KAYA *et al.,* 2008). The percent of black seed inbred lines in more than 95% of the collection was affected by the low values of the *Shannon* index. Also, the traits of seed shape and size had low discriminatory power, which was in correlation with the fact that it is possible to find different seed sizes in one sunflower head according to their distance from the center of the head (MIRZABE *et al.,* 2012). Regarding the seed size the collection was not heterogenic, because this collection was not used for confectionary sunflower breeding (TAN and TAN, 2010).

It was noticed that HOMLAS analyses and *Shannon* diversity do not favor the same traits, which is in accordance with other studies on sunflower and other crops (PERIĆ, 2015; RADINOVIĆ, 2016; HLADNI *et al.,* 2017).

CONCLUSIONS

The results of the present study indicated that inbred lines in the collection have very high degree of diversity for the following traits: hypocotyl anthocyanin coloration, leaf color, leaf angle of the lowest veins, leaf height of the tip of the blade, ray floret density, bract position and seed stripes between and on the margins. The traits with the highest discriminatory power were disk flower anthocyanin coloration of stigma, hypocotyl anthocyanin coloration, leaf blistering, leaf serration, seed stripes on margin and seed stripes between margins. According to these traits inbred lines were divided in two large groups and three subgroups. Inbred lines showed the great variability of morphological traits in the whole collection and also among the inbred lines from the same type of use. If heterosis is exhibited in crosses with divergent genotypes, it would be useful to examine if inbred lines that are different according to morphological traits would give hybrid vigor.

ACKNOWLEDGMENTS

This study was supported by Ministry of Education, Science and Technological Development of Republic of Serbia, project TR31025 and Provincial Secretariat for Higher Education and Science of Vojvodina, project 114-451-2126/2016-03.

Received, September 21st, 2019

Accepted April 22nd, 2020

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VARIJABILNOST MORFOLOŠKIH OSOBINA INBRED LINIJA SUNCOKRETA

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Izvod

Pored agronomski važnih osobina, velika varijabilnost suncokreta je prisutna u morfološkim osobinama i veoma su korisne u oplemenjivačkim programima. Osnovni cilj ovog rada je bio da se utvrdi genetička varijabilnost 110 inbred linija iz kolekcije Instituta za ratarstvo i povrtarstvo Novi Sad (IFVCNS) na osnovu ispitivanja 34 morfološke osobine prema listi deskriptora Međunarodne unije za zaštitu novih sorti biljaka (UPOV) koje se koriste za određivanje DUS testa (test različitosti, ujednačenosti i stabilnosti). Varijabilnosti morfoloških osobina je proceenjena *Shannon*-ovim indeksom raznolikosti (*H'*), a varijabilnost inbred linija suncokreta izvršena je analizom homogenosti (HOMALS) kao i diskriminatorna snaga ispitivanih osobina. Najviše vrednosti *Shannon*-ovog indeksa divergentnosti bile su za visinu vrha liske u poređenju sa dužine lisne drške i položaj brakteja (*H'=0,99*), dok su grananje, oblik glave i boja semena pokazali najniži raznovrsnost (*H'>0,1*). Ujednačenost distribucije inbred linija odredila je diskriminativnu moć deskriptora. Najveću diskriminatornu moć imale su prisustvo antocijana na stigmi trubastih cvetova, intenzitet i boja antocijana na hipokotilu, naboranosti lista, nazubljenost lista, pruge na marginama semena i pruge između margina. Na osnovu ovih šest osobina kolekcija inbred linija je podeljena u dve glavne grupe i tri podgrupe koje bolje objašnjavaju odnose između različitih inbred linija. Inbred linije su pokazale veliku varijabilnost morfoloških osobina u celokupnoj kolekciji, ali i među inbred linijama istog tipa upotrebe.

Primljeno 21. IX.2019.
Odobreno 22. IV. 2020.