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Assessment of Genetic Diversity Among Sunflower Inbred Lines for the Development of Recombinants having Better Achene Yield and Oil Quality

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Abstract: Assessment of genetic diversity in germplasm is prerequisite for the success of any plant breeding program. Twenty-four Sunflower inbred lines including 15 cytoplasmic male sterile lines (A lines) and nine fertility restorer lines (R lines) were sown to estimate genetic dissimilarities at research area of Oilseeds Research Institute, Faisalabad (Pakistan) during Spring 2018. The objective of study was identification of superior inbred lines to be utilize as parental inbred lines for the development of better recombinants and estimation of association among important qualitative and quantitative characters. Data revealed that Sunflower inbred lines possessed noticeable genetic variation and have potential for utilization in hybrid development program. Among A lines, ORI-92, ORI-94 and ORI-25 has proved their worth for good seed yield and can be employed in crossing with R lines RL-66, RL-68 and RL-50 having high Oleic acid content may give a better recombinant as they displayed high degree of genetic divergence among them. Moreover, yield had positive relationship with head diameter and Linoleic acid while negative relationship with Oleic acid.

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1. Introduction

Edible oil is Pakistan's largest food import commodity ranking third in the import list after petroleum products and machinery. Pakistan is dependent upon other countries to fulfill more than 80% edible oil requirement and spending a big amount of foreign exchange every year. The local production of edible oil is less than 20% of country's requirements (Aftab *et al.,* 2019). Domestically 0.50 million tons of edible oil was produced during the year 2018-19 whereas 2.421 million tons of oil worth Rs. 192.20 billion was imported to undertake the constantly growing demand of edible oil (Economic Survey of Pakistan, 2018-19). This situation is posing huge burden to national economy. Considering, the importance of local edible oil production, Government of Pakistan has taken initiative to enhance local production by increasing the area under oilseed crops and availability of high yielding hybrids/varieties of oilseed crops. Sunflower is an important oilseed crop of Pakistan and ranked 2nd after Rapeseeds and Mustards. Moreover, its oil quality with greater content of unsaturated fatty acids also increase its importance from health point of view in current scenario of increasing cardiac issues. Sunflower has a short growing period with wider adaptability which makes it suitable for different cropping pattern and agro-ecological zones of Pakistan (Aftab *et al.,* 2019).

Sunflower hybrids have more importance in agricultural system of Pakistan because of its higher yield, good oil quality and disease resistance but unfortunately no local sunflower hybrid is cultivated in the field at this time. Farmers have to grow imported high cost sunflower hybrids which have less adaptability in local environmental conditions. For this purpose, locally developed sunflower hybrids are direly needed which is only possible through the utilization of locally developed genetic stock of inbred lines. The genetic stock of inbred lines (A, B and R lines) having desirable qualitative and quantitative characters is the key of success towards the development of potential Sunflower hybrids. Existence of genetic diversity among the inbred lines provides an opportunity for plant breeders to develop

hybrids with desirable features. The main issue of hybrid breeding is the utilization of heterosis which is mainly related to the genetic distance among inbred lines, so, further relatives exhibit higher heterosis. Therefore, a plant breeder should know the genetic relationship of inbred lines to obtain higher yield which is the major goal (Hladni *et al*., 2008).

Principle component analysis has been proved to be a very useful statistical tool in identifying genotypes with superior performance and classifying lines based on genetic distance in many crops like sunflower (Rehman *et al*., 2012; Iqbal *et al*., 2013; Hussain *et al*., 2017; Venujayakanth *et al*., 2017), wheat (Hailu *et al*., 2006), black gram (Ghafoor and Arshad, 2005). Principle component analysis also helps to determine inbred lines which can be used as parents to improve sunflower seed yield and oil contents (Kholgi *et al*., 2011). This study was organized with the objective of assessing variability among sunflower inbred lines at genetic level and to utilize the outcomes in future sunflower improvement programs.

2. Material and Methods

During spring, 2018, 24 Sunflower inbred lines were planted thrice in a randomized complete block design at the research farm of Oilseeds Research Institute, Faisalabad (Pakistan). The inbred lines with prefix "ORI" represent the cytoplasmic male sterile lines (A lines) whereas prefix "RL" represents the fertility restorer (R lines). The data were noted down from 10 arbitrarily selected plants from each replication. Standard agronomic and plant protection practices were carried out during the conduct of whole experiment. Recommended dose of NPK (118:85:62 kg/ha) was applied. The field was irrigated 5 times due to the extreme weather conditions during critical growth stages. After the completion of physiological maturity (100–110 days) data were noted for head diameter (HD), days to maturity (DTM), achene yield per plant (AYP), oil contents (OC), oleic acid (OA) and linoleic acid (LA). Oil percentage was determined through Near Infra-Red Spectroscopy (NIR) at Oil technology laboratory, Oilseeds Research Institute, Faisalabad (Pakistan).

Table 1: List of twenty-four inbred lines of sunflower developed by Oilseeds Research Institute, Faisalabad (Pakistan).

Sr. No.	Inbred lines	Sr. No.	Inbred lines
1	ORI-2	13	ORI-95
2	ORI-7	14	ORI-99
3	ORI-10	15	ORI-100
4	ORI-19	16	RL-38
5	ORI-20	17	RL-39
6	ORI-21	18	RL-50
7	ORI-22	19	RL-66
8	ORI-23	20	RL-67
9	ORI-25	21	RL-68
10	ORI-26	22	RL-86
11	ORI-92	23	RL-100
12	ORI-94	24	RL-109

2.1. Statistical Analysis:

Data noted for various characters were investigated through analysis of variance (Steel *et al*., 1997) to assess the presence of useful genetic variability by using statistics 8.1 and genotypes were selected through GGE biplot analysis (Yan *et al*., 2000) by using XLSTAT version of Microsoft Excel, Copyright Addinsoft 1995-2012 (http://www.xlstat.com). LSD test at P = 0.05 is used to access the association among treatments for yield or yield components. Principle component analysis is used to calculate the mathematical analysis or simple statistical analysis.

3. Results

Variance analysis displayed that sunflower inbred lines had evidently variable performance for characters associated with seed yield and oil quality (Table No. 2). Means of studied traits (Table No. 3) showed that inbred line ORI-92 takes maximum number of days to reach its maturity stage and had highest HD. Among all inbred lines, ORI-25 and ORI-94 displayed uppermost AYP. Inbred line RL-67 had highest percentage of OC followed by ORI-19. Maximum percentage of OA was exhibited by RL-50 whereas lowest OA was presented by ORI-100. Among R lines, RL-86 had highest LA percentage whereas lowest was displayed by RL-100. The principal components having more than 1 eigen value are presented in Table No. 4. First two PCs contribute 62% in total variability. First principle component

point outs the importance of HD, AYP and LA and suggested the positive association between these variables. Inbred lines that fall in PC1 vary together for observed characters. Second principle component is associated with DTM and OC. These variables have negative association between them.

Similar results have been displayed in graphical presentation of bi-plot analysis (Fig. 1) in which PC1 is laid against PC2. Length and direction of vectors in Fig. 1 represents the extent and direction of variability among characters under investigation. Plotting of various inbred lines in four quadrates displayed their worth in terms of genetic diversity present among them and helps in their selection for inclusion in hybridization program for getting desirable recombinants. Inbred lines that are plotted along the vectors associated with various characters had high degree of variability for that character. Inbred lines ORI-94 and ORI-25 showed its worth for AYP, HD and OC whereas the inbred line ORI-92 have good percentage of LA and had long maturity duration. RL-68, RL-67 and RL-66 displayed their value for OA content. Associations among various characters are very much important to design selection criterion for the development of desirable cross combinations. Substantially positive association was observed between AYP, HD and LA whereas negative relationship was observed for these characters with OA. LA had negative association with OA (Qamar *et al*., 2018).

Table 2: Mean squares for yield and oil quality related parameters in sunflower inbred lines.

SOV	DF	HD	DTM	AYP	OC	OA	LA
Replications	2	7.063	0.0007	98.13	0.148	8.0	14.79
Inbred lines	23	47.75	55.54	267.5	38.20	420.3	524.2
Error	46	3.81	0.0001	49.58	4.83	9.96	14.66
Total	71						

SOV = Source of variation, DF = degrees of freedom, HD = Head diameter, DTM = days to maturity, AYP= Achene yield per plant, OC = Oil contents, OA = Oleic acid, LA = Linoleic acid

Table 3: Mean values for achene yield and oil related characters in sunflower inbred lines

Sr. No.	Inbred line	HD	DTM	AYP	OC	OA	LA
1	ORI-2	14.58	99.00	19.20	34.70	61.31	39.31
2	ORI-7	17.25	99.00	24.65	35.09	40.00	42.14
3	ORI-10	9.50	96.00	20.37	38.59	38.61	56.46
4	ORI-19	12.50	96.00	25.55	43.12	40.09	36.94
5	ORI-20	14.33	96.00	26.28	40.45	45.96	44.34
6	ORI-21	17.33	98.00	30.42	40.57	44.33	42.93
7	ORI-22	12.50	96.00	23.52	42.64	49.53	41.55
8	ORI-23	13.33	95.00	11.65	33.02	43.38	41.46
9	ORI-25	16.83	94.00	35.64	40.17	40.90	40.62
10	ORI-26	16.00	98.00	25.07	42.59	47.78	43.46
11	ORI-92	17.50	112.00	25.28	35.02	37.07	55.86
12	ORI-94	13.67	97.00	35.46	39.21	35.84	59.30
13	ORI-95	13.33	103.00	7.21	35.76	35.10	29.49
14	ORI-99	14.33	103.00	26.44	39.71	43.27	34.37
15	ORI-100	17.00	95.00	25.24	39.60	34.31	43.79
16	RL-38	13.00	101.00	14.62	37.92	66.28	29.82
17	RL-39	14.00	97.00	28.10	36.60	66.55	23.87
18	RL-50	12.00	98.00	22.82	40.51	71.61	16.87
19	RL-66	7.00	98.00	8.51	37.17	63.84	25.25
20	RL-67	5.67	100.00	8.00	45.37	51.57	15.12
21	RL-68	6.00	91.00	4.57	36.13	63.60	24.77
22	RL-86	5.67	98.00	7.35	33.33	61.01	59.70
23	RL-100	5.33	96.00	5.83	31.06	36.59	13.69
24	RL-109	13.67	106.00	15.41	35.83	56.73	40.92

HD = Head diameter, DTM = days to maturity, AYP = Achene yield per plant, OC = Oil contents, OA = Oleic acid, LA = Linoleic acid

Table 4: Principal component analysis for sunflower inbred lines

	PC 1	PC 2
Eigen value	2.46	1.30
Proportion	0.41	0.21
Cumulative	0.41	0.62
Variables		
Head diameter (cm)	0.55	0.03
Days to maturity (days)	0.14	0.55
Achene yield per plant (g)	0.55	-0.28
Oil contents (%)	0.20	-0.69
Linoleic acid (%)	0.42	0.29
Oleic acid (%)	-0.37	-0.19

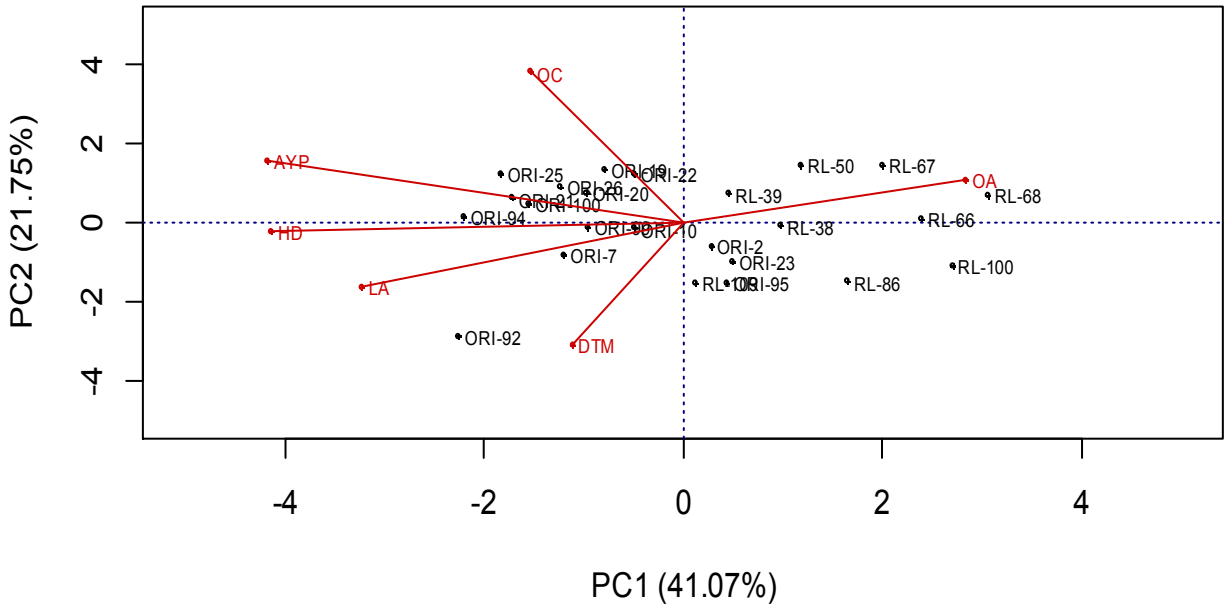

Fig. 1. Bi-plot analysis for sunflower inbred lines for yield and oil quality related characters.

4. Discussion

Extent and direction of differences in available germplasm in terms of genetic makeup provides chance for breeders to develop appropriate genotypes. Studied inbred lines displayed clear differences in their genetic makeup which suggests their value for selection and utilization in hybrid development program. Principal component analysis showed existence of genetic divergence which suggested the presence of contrasting and complementary traits among inbred lines and their utilization may be fruitful in development of desirable recombinants having good yield potential and oil quality. Crossing among genetically divergent parents like ORI-94, ORI-92 and ORI-25 with fertility restorer parents like RL-66, RL-68 and RL-50 are expected to raise the hybrids having better heterotic potential. Genetic diversity between parents of the crosses indicates differences in gene frequency, which can be exploited to improve inbred or parental lines (Ram *et al*., 2018).

Significance of relationship is important among characters for launching an effective hybrid development program as it offers a chance for selection of appropriate inbred line with desirable traits simultaneously (Ali *et al*., 2009). Correlation studies had revealed some important associations among yield and oil quality related parameters. AYP had significant and positive relationship with HD and LA, Negative association between OA and LA (Qamar *et al*., 2018; Neto *et al*., 2016) suggested that these two important fatty acids cannot be improved simultaneously. Aguirrezabal *et al*. (2015) develop

conceptual models, which suggested that change in oil and fatty acid contents may be due to the function of carbohydrates.

5. Conclusion

Analysis of variance suggested the presence of variation in available germplasm. ORI-94, ORI-92 and ORI-25 exhibited its value for Achene yield per plant (AYP), Head diameter (HD) and Linoleic acid (LA) whereas RL-50, RL-68 and RL-66 is important for its Oleic acid (OA) content. Cytoplasmic male sterile lines and fertility restorer lines that falls in opposite quadrates are important in terms of hybrid development program as genetically divergent parents are prerequisite for development of high-profile hybrids. Moreover, relationship among characters showed that Achene yield per plant (AYP) can be improved by improving Head diameter (HD). Among quality factors, both important fatty acids like Linoleic acid (LA) and Oleic acid (OA) cannot be improved simultaneously. While to increase the stability of oil in new Sunflower hybrids, high Oleic acid male parents and female parents having good yield contributing traits can be utilized in cross combination for the development of high Oleic acid Sunflower hybrids with better seed yield.

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