

Fatty Acid Composition of Sunflower in 31 Inbreed and 28 Hybrid

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ABSTRACT

High variability observed represents a very promising base to obtain new sunflower inbreds with high oil quality for use either as component in hybrids or as breeding stock for future generations. The high variability observed also suggests that selection in sunflower germplasm enable the creation of more oil profiles with different fatty acids. Further research has advanced to clarify the inheritance of fatty acids to generate superior hybrid. The important high accumulation of unsaturated fatty acids genotype are GP-01004, Entry no-20, GP-01009 and GP-04026 can be utilized further to develop a sunflower hybrids with high and good quality fatty acid. Among derived crosses, four crosses were found to be higher oleic acid content viz., GP-01009x Entry P-S-2 (58.57%), BHAC-04038 (1) x GP-01005 (56.85%), Entry no.-20 x GP-01009 (53.36%) and BHAC-04038 (1) x GP-01009 (52.05%) compared to their respective parent (Table 1). Whereas involving parents GP-01009, Entry P-S-2, BHAC-04038 (1), GP-01005 and Entry no.-20 of these crosses contain 25.15%, 38.90%, 27.67%, 18.11% and 18.71% oleic acid (Tables 2 & 3) respectively can be utilized high oleic containing hybrid.

Introduction

Vegetable oil consists of different types of saturated and unsaturated fatty acids (palmitic acid, stearic acid, oleic acid, linoleic acid etc.). The palmitic acid and stearic acid are the major saturated fatty acids whereas oleic and linoleic acids are unsaturated. The sunflower oil contains more of unsaturated fatty acids, mainly oleic acid and linoleic acid and very less quantity of saturated fatty acid, palmitic acid and stearic acid. Healthy oil should contain more of unsaturated fatty acids compared to saturated fatty acids. The quality of sunflower oil is generally associated with the relative concentration of oleic and linoleic acid. Oil with high oleic acid content has several benefits with regard to human health. High levels of saturated fat (Palmitic and stearic acid) consumption are correlated with increased risk of coronary heart disease. Oils with high oleic content are resistant to heat oxidation, longer shelf life and low cholesterol effect. However, Roberston reported that linoleic acid content varied inversely with the oleic acid content.

High proportion of the essential fatty acid (18:2) is considered to reduce blood cholesterol and hence sunflower has a special

significance. High linoleic sunflower with 70% linoleic acid is also available in studied germplasm. It has greater oxidative stability and is useful as frying oil in the preparation of snack foods. Furthermore, sunflower oil contains fat soluble vitamins A, B, E and K, well for heart proteins [1]. The objective of this study was to make a review of the genetic variability of oil quality components in sunflower and inheritance pattern in cross combination using own results and those of other authors.

Materials and Methods

Estimation of Fatty Acid Composition

Fatty acid profile of 31 inbreds and 28 F1 derived from selected eight parent through half diallel fashion was estimated by using gas chromatography. About 8-12 seeds was taken (seed was crushed in an oil paper and then transferred into a test tube). The sample was extracted and trans esterified at the same time with 5 ml ethylated reagent (petroleum ether/0.02M sodium hydroxide in ethanol (2/3) and shake. The samples were kept for overnight at room temperature. 10 ml salt solution (80 g NaCl and 3 g sodium hydrogen

sulphate in 1 liter water) was added and shake. As soon as the two layers were separated, the benzene phase was transferred to small test tubes. A Philips PU 4500 chromatograph instrument was used with Flame Ionization Detector (FID). A glass column (1.5m x 4mm) was packed with BDS. With this column the injection post, column and detector temperature was set at 220°C, 185°C and 240°C, respectively. Nitrogen flow (used as carrier gas) rate was 22 ml/min, the injection volume was 2 µl. Peak areas were measured with an electronic digital integrator (Shinadzu C-R6A chromatopac).

Results and Discussion

The sunflower fatty acid profile includes estimation of various proportion of palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1), linoleic acid (C18:2), arachidic acid (C20:0), linolenic acid (C18:3) and cis-ecosenoic (20:1) expressed in terms of percentages. The results obtained for seven fatty acids of 31 inbreds line through gas chromatography are presented in Table 4, Total fatty acid composition (Saturated and un-saturated) of the different inbred lines presented in Table 2, fatty acid composition of selected inbred parents used in half diallel crosses in sunflower are presented in Table 1 and fatty acid profile of 28 F1 derived from selected eight parent are presented in Table 4.

Table 1: Fatty acid composition of the 31 inbred lines of sunflowers.

Inbreds		Percentage of Fatty Acids						
Sl no.	Designation	Saturated Fatty Acid (SFA)			Unsaturated Fatty Acid (USFA)			
		Palmitic Acid (C16:0)	Stearic Acid (C18:0)	Arachidic Acid (C20:0)	Oleic Acid (C18:1)	Linoleic Acid (C18:2)	Linolenic Acid (C18:3)	Cis-ecosenoic (20:1)
G1	BHAC-SH-037	6.2311	1.9822	0.32011	34.5679	55.6783	0.0459	0.0780
G2	Sun-W-101	7.7211	5.4484	0.4336	31.1099	54.0554	0.1173	0.1446
G3	Sun- W-103	6.0801	2.0269	0.5284	44.7745	45.2137	0.0852	0.0955
G4	BHAC-04032	7.9893	1.4061	0.2909	22.2583	67.3469	0.1323	0.0698
G5	BHAC-P-S-2	8.4618	1.9625	0.4207	25.5723	62.5897	0.0909	0.0264
G6	BHAC-04038(1)	6.0567	1.7843	0.4563	27.6745	63.8763	0.0875	0.0453
G7	BHAC-04026	8.5301	0.8514	0.3384	28.3661	60.7532	0.1201	0.0584
G8	BHAC-04028	6.0432	1.4194	0.4843	40.3115	50.5877	0.0594	0.0949
G9	BHAC-04016	6.9573	3.7103	0.3151	29.0428	57.2838	0.1348	0.2070
G10	Entry no-20	8.1312	2.3065	0.1999	18.7108	69.8911	0.1703	0.2201
G11	Entry no-21	6.3434	4.6143	0.2715	28.2267	59.0254	0.1348	1.0000
G12	Entry no-22	6.4245	6.2167	0.14689	37.2898	47.7176	0.4276	1.0000
G13	Entry no-23	8.2963	1.2503	0.2705	33.1717	55.9953	0.0987	0.0732
G14	Entry no.P-S-2	6.0635	2.5317	0.2669	38.9009	51.3562	0.0668	0.1246
G15	GP-01002	7.4113	5.1763	0.5016	25.3153	60.6179	0.0020	0.1662
G16	GP01004	6.5012	5.1353	0.341	40.1636	46.7211	0.0690	0.1100
G17	GP-01005	7.4773	5.3527	0.3678	18.1084	67.8176	0.0591	0.0012
G18	GP-01009	6.2744	6.0924	0.3098	25.1556	60.9614	0.2323	0.3100
G19	GP-04011	8.6344	2.4451	0.2404	26.0249	61.9957	0.0914	0.0874
G20	GP-04012	6.3746	4.8316	0.3228	29.6585	56.6076	0.0923	0.0891
G21	GP-04015	6.5214	3.4655	0.2742	25.4531	63.4574	0.0988	0.1243
G22	GP-04016	6.6776	3.4314	0.2017	23.4684	64.8983	0.1414	0.1336

Saturated Fatty Acid

The hybrids with a high content of saturated fatty acids will have an important impact on the food industry because their oil will permit the production of semi-solid fats without the need of health-detrimental processes such as hydrogenation or trans esterification [2]. But as daily intake for frying oils its percentage should be minimum. Onemli [3], Praveen [4] reported saturated fatty acid exhibit significant variation among their studied germplasm. In this study out of seven fatty acid estimated in parental inbred lines palmitic acid (C16:0), stearic acid (C18:0) and arachidic acid (C20:0) are in group of saturated fatty acid. Palmitic acid (C16:0) range 0.17 -2.41, stearic acid (C18:0) range 0.30-7.96 and arachidic acid (C20:0) range 0.02-5.52 indicates inbreds are differ from one to another for different kinds of saturated fatty acid (Table 1). Total saturated fatty acid range from 7.95- 13.60 (Table 2). Selected inbreds that used for crossing in half diallel fashion it ranges 6.27-8.46 for palmitic acid, 1.25-6.09 for stearic acid and 0.20-0.46 for arachidic acid respectively (Table 3). In crossing generation develop through selected inbreds it ranges 4.58-6.88 for palmitic acid, 1.96-5.17 for stearic acid and 0.20-0.39 for arachidic acid respectively.

G23	GP-04017	6.5205	5.6109	0.2696	17.0873	67.4096	0.3181	0.2627
G24	GP-04018	6.3144	4.4272	0.2929	28.4428	59.4558	0.1576	0.1299
G25	GP-04019	5.7923	6.1755	0.1265	43.6844	42.3745	0.4234	0.2070
G26	GP-04023	5.9758	3.8181	0.266	31.2023	57.1553	0.0894	0.1048
G27	GP-04024	6.8573	3.9103	0.4151	28.0428	55.2838	0.1447	0.2080
G28	GP-04026	7.3145	5.0245	0.3024	19.5954	66.2245	0.1585	0.7934
G29	GP-04028	5.2543	3.7103	0.3798	24.6706	60.8798	0.1480	0.1227
G30	GP-04030	6.4347	5.4827	0.2564	24.2609	62.2216	0.0954	0.0004
G31	GP-04038(2)	7.9266	3.7103	0.2618	29.0428	18.3698	0.0988	0.1545
Over all mean		6.95	3.72	0.38	29.01	57.22	0.13	0.21
SD		0.1675	0.2960	0.0176	1.3032	1.7989	0.0173	0.0492
CV(%)		2.41	7.96	5.52	4.49	3.14	12.79	23.73
Maximum		8.63	6.22	0.53	44.77	69.89	0.43	1.00
Minimum		5.25	0.85	0.13	17.08	18.37	0.002	0.0004

Table 2: Total fatty acid composition (Saturated and un-saturated) of the different inbred lines.

Inbreds		Percentage of Fatty Acids		
Sl no.	Designation	Total saturated fatty acid (SFA)	Total un-saturated fatty Acid (SFA)	Total fatty acid (TFA)
G1	BHAC-SH-037	8.5334	90.3701	98.9035
G2	Sun-W-101	13.6031	85.4272	99.0303
G3	Sun- W-103	8.6354	90.1689	98.8043
G4	BHAC-04032	9.6863	89.8073	99.4936
G5	BHAC-P-S-2	10.845	88.2793	99.1243
G6	BHAC-04038(1)	8.2973	91.6836	99.9809
G7	BHAC-04026	9.7199	89.2978	99.0177
G8	BHAC-04028	7.9469	91.0535	99.0004
G9	BHAC-04016	10.9827	86.6684	97.6511
G10	Entry no-20	10.6376	88.9923	99.6299
G11	Entry no-21	11.2292	88.4596	99.6888
G12	Entry no-22	12.7880	86.545	99.33309
G13	Entry no-23	9.8171	89.3389	99.156
G14	Entry no.P-S-2(1)	8.8621	90.4485	99.3106
G15	GP-01002	13.0892	86.1014	99.1906
G16	GP01004	11.9775	87.0637	99.0412
G17	GP-01005	13.1978	85.9863	99.1841
G18	GP-01009	12.6766	86.6593	99.3359
G19	GP-04011	11.3199	88.1994	99.5193
G20	GP-04012	11.529	86.4475	97.9765
G21	GP-04015	10.2611	89.1336	99.3947
G22	GP-04016	10.3107	88.6417	98.9524
G23	GP-04017	12.401	85.0777	97.4787
G24	GP-04018	11.0345	88.1861	99.2206
G25	GP-04019	12.0943	86.6893	98.7836
G26	GP-04023	10.0599	88.5518	98.6117
G27	GP-04024	11.1827	83.6793	94.862
G28	GP-04026	12.6414	86.7718	99.4132
G29	GP-04028	9.3444	85.8211	95.1655
G30	GP-04030	12.1738	86.5783	98.7521
G31	GP-04038(2)	11.8987	47.6659	59.5646

Over all mean	10.93	86.57	97.50
Standard Deviation	1.57	7.47	7.13
CV	14.34	8.63	7.31
Minimum	7.95	47.67	59.56
Maximum	13.60	91.68	99.98

Table 3: Fatty acid composition of selected inbred parents used in half diallel crosses in sunflower.

Inbreds		Percentage of Fatty Acids						
Sl no.	Designation	Saturated Fatty Acid (SFA)			Unsaturated Fatty Acid (USFA)			
		Palmitic Acid (C16:0)	Stearic Acid (C18:0)	Arachidic Acid (C20:0)	Oleic Acid (C18:1)	Linoleic Acid (C18:2)	Linolenic Acid (C18:3)	Cis-eicosenoic (20:1)
G1	BHAC-P-S-2	8.4618	1.9625	0.4207	25.5723	62.5897	0.0909	0.0264
G2	BHAC-04038(1)	6.0567	1.7843	0.4563	27.6745	63.8763	0.0875	0.0453
G3	Entry no-20	8.1312	2.3065	0.1999	18.7108	69.8911	0.1703	0.2201
G4	Entry no-23	8.2963	1.2503	0.2705	33.1717	55.9953	0.0987	0.0732
G5	GP-01004	6.5012	5.1353	0.341	40.1636	46.7211	0.069	0.1100
G6	GP-01005	7.4773	5.3527	0.3678	18.1084	67.8176	0.0591	0.0012
G7	GP-01009	6.2744	6.0924	0.3098	25.1556	60.9614	0.2323	0.3100
G8	GP-04026	7.3145	5.0245	0.3024	19.5954	66.2245	0.1585	0.7934
Over all mean		7.56	3.61	0.33	26.02	61.76	0.12	0.20
SD		0.83	1.96	0.08	7.67	7.44	0.06	0.26
CV(%)		10.91	54.19	24.63	29.49	12.05	49.76	132.95
Minimum		6.27	1.25	0.20	18.11	46.72	0.06	0.001
Maximum		8.46	6.09	0.46	40.16	69.89	0.23	0.79

Palmitic Acid

Standard sunflower genotypes contains to 5-6% palmitic acid. Onemli [3], Praveen [4] observed significant variation for palmitic acid (C16:0) in sunflower genotype. A low level palmitic acid is preferred from human health point of view. Palmitic acid is believed to increase LDL (low density lipoprotein), which is associated with cardiovascular disease risk. In the present study the palmitic acid ranges in parental line 5.25-8.63%. Proportion of palmitic acid was low in parental line lines GP-04028 (5.25%) and GP-04019 (5.79%), in selected parent that used for crossing in half diallel fashion lines the lowest recorded was GP-01009 (6.27%) and GP-04026 (7.31%), while in 28 derived crosses, it ranged from 4.58 to 6.88 percent. The lowest proportion of palmitic acid in derived crosses was BHAC-04038(1)xGP-01005 (4.58%), Entry no-20xGP-01004 (4.67%) and GP-01009xEntry-P-S-2 (4.97%). Praveen (2015) reported palmitic acid range 4.43-10.93%, Skoric, mentioned palmitic acid may vary 3.0-11.5% and according to Anon. 2015-16 palmitic acid ranges 5-8 percent in sunflower.

Stearic Acid

Stearic acid is categorized as saturated fatty acid, the higher concentrations is an undesirable oil quality characteristic. In case of parental lines, the low proportion was recorded in BHAC-04026 (0.85%), Entry no-23 (1.25%) and BHAC-04038 (1.41%) and stearic acid ranges in parental line 0.85-6.22%, in selected lines for half diallel crosses it was lowest in Entry no-23 (1.25%), BHAC-

04038(1) (1.78%) and BHAC-P-S-2 (1.96%) and it ranges 1.25-6.09. While in 28 derived crosses it recorded very low proportion from 1.96 to 5.17 percent. In case of hybrid low proportion was recorded in cross combination GP-01004x Entry-P-S-2 (1.96%), GP-01009x Entry-23 (2.45%) and GP-01004x GP-01005 (3.02%). This result is in accordance with the report of Skoric et al. where they conclude stearic acid may vary 0.6-6.2% in sunflower, Praveen [4] recorded range of stearic acid 0.09-5.27% and stearic acid 4-6 per cent [5].

Arachidic Acid

Arachidic acid is also a saturated fatty acid which found <1% in sunflower. High concentration of this fatty acid is undesirable for human health. FAO/WHO [6] reported arachidic acid is responsible for cardiovascular disease (DVD), coronary heart disease. In this study arachidic acid range in parental line was 0.13-0.53%. The lowest proportion of arachidic acid found in the inbreds GP-04019 (0.13%), Entry no-22 (0.15%) and Entry no-20 (0.20%). In selected parent those were used in crossing programme in half diallel fashion ranges 0.20-0.46%. In derived 28 F1 arachidic acid ranges from 0.20-0.39%. The lowest proportion of arachidic acid in derived F1 was found in the cross combination GP-01004x GP-01005 (0.1959%), GP-01009x Entry-23 (0.2093%), GP-01004x Entry-23 (0.2135%) and GP-01004x Entry P-S-2 (0.2178%).

Unsaturated Fatty Acid (UFA)

The sunflower oil had more than 90% of the unsaturated fatty acids and variation was noted among parents as well as hybrids

regarding un-saturated fatty acid profile. Among unsaturated fatty acids, the linoleic and oleic is dominant in classical sunflower. There is an important genetic variation regarding the fatty acid composition of the sunflower oil. [7,8]. In this study UFA varied 47.67-91.68 percent which found in the inbred line GP-04038(2) and BHAC-04038(1) respectively. The inbred lines BHAC-04028 (91.0535%), Entry no.P-S-2(1) (90.4485%), BHAC-SH-037 (90.3701%) and Sun-W-103 (90.1689) contain more than 90% unsaturated fatty acid. Other inbreed contain 80-90% unsaturated fatty acid except only one inbreed GP-04038(2) which contain 47.66% UFA. Kostik and Bauer; Skoric et al. [9] reported sunflower oil contain the highest percentage of long chain mono and polyunsaturated fatty acids than other vegetables oil sources. According to FAO/WHO [6] UFA especially Poly Unsaturated Fatty Acid (PUFAs) is essential on human health in the prevention of particularly, cardiovascular disease (DVD), coronary heart disease.

Oleic Acid

High proportion of the essential fatty acid (18:2) is considered to reduce blood cholesterol and hence sunflower has a special significance [10]. It has greater oxidative stability and is useful as frying oil in the preparation of snack foods. High oleic acid also serves as a source of oleic acid useful in preparation of cosmetics and pharmaceuticals. The oleic acid proportion in sunflower genotypes varies from 30 to 90 percent and generally the genotypes have

been classified into three classes viz., low oleic (10-29%), mid oleic (30-59%) and high oleic (60-90%) (Lacombe and Bervillé, 2001, Pecureanu-Joita 2005). In present study the range of oleic acid varied greatly from 4.49 percent to 44.77 percent. Among 31 inbred majority of inbred viz. BHAC-04032, BHAC-P-S-2, BHAC-04038(1), BHAC-04026, BHAC-04016, Entry no-21, GP-01002, GP-01005, GP-01009, GP-04011, GP-04012, GP-04015, GP-04016, GP-04017, GP-04018, GP-04023, GP-04024, GP-04026, GP-04028, GP-04030 and GP-04038(2) are in low oleic group and 10 inbred viz. GP-04019, GP01004, Entry no.P-S-2(1), Entry no-23, Entry no-22, Entry no-20, BHAC-04028 and Sun-W-103 exhibits mid oleic content.

Among selected parent oleic acid ranges from 18.11-40.16% (Table 3). Among derived crosses, four crosses were found to be higher oleic acid content viz., GP-01009x Entry P-S-2 (58.57%), BHAC-04038(1) x GP-01005 (56.85%), Entry no.-20 x GP-01009 (53.36%) and BHAC-04038(1) x GP-01009 (52.05%) compared to their respective parent. Whereas involving parents GP-01009, Entry P-S-2, BHAC-04038(1), GP-01005 and Entry no.-20 of these crosses contain 25.15%, 38.90%, 27.67%, 18.11% and 18.71% oleic acid (Table 4) respectively. Onemli (2012), Praveen (2015) explain significant variation for oleic acid while investigating fatty acid profile in sunflower oil. Kostik and Bauer [9] reported oleic acid ranges 27-36 percent, Rosa (2014) found oleic acid range 20-25%, Praveen [4] observed oleic acid 24.63-84.97% in their study.

Table 4: Fatty acid profile of F1 generation of selected eight parents developed through half diallel fashion.

Inbreds	Percentage of Fatty Acids						
	Saturated Fatty Acid (SFA)			Unsaturated Fatty Acid (USFA)			
	Palmitic Acid (C16:0)	Stearic Acid (C18:0)	Arachidic Acid (C20:0)	Oleic Acid (C18:1)	Linoleic Acid (C18:2)	Linolenic Acid (C18:3)	Cis-eicosenoic (20:1)
Entry no.-20 x BHAC-04038(1)	6.4547	3.367	0.2773	29.977	58.9471	0.0757	0.1525
Entry no.-20x GP-01004	4.6996	3.813	0.316	47.9099	42.2706	0.0772	0.1536
Entry no.-20x GP-01005	6.0676	3.6139	0.2955	34.0137	54.9263	0.0922	0.1400
Entry no.-20x GP-01009	5.4604	3.1893	0.2734	53.3699	36.5458	0.0997	0.2205
Entry no.-20x GP-04026	6.3626	4.1047	0.293	37.5991	50.36	0.0837	0.1244
Entry no.-20x Entry-23	6.5916	4.2828	0.2288	23.9345	64.0861	0.1079	0.1090
Entry no.-20x Entry P-S-2	5.7898	4.6149	0.2443	34.5122	53.9819	0.0755	0.0889
BHAC-04038(1)x GP-01004	5.8682	3.7117	0.2749	35.1755	53.9188	0.0978	0.1427
BHAC-04038(1)x GP-01005	4.581	3.089	0.2744	56.8591	34.2852	0.0010	0.1656
BHAC-04038(1)x GP-01009	5.0218	5.1661	0.3908	52.0538	35.5439	0.1535	0.2027
BHAC-04038(1)x GP-04026	5.7854	3.7338	0.245	34.8341	54.6678	0.0434	0.0949
BHAC-04038(1)x Entry-23	5.586	3.0349	0.2388	24.4293	65.8399	0.0878	0.0946
BHAC-04038(1)x Entry P-S-2	5.8882	4.1271	0.232	38.7072	50.1929	0.0831	0.2320
GP-01004x GP-01005	6.3964	3.023	0.1959	15.845	73.7622	0.0866	0.1344
GP-01004x GP-01009	6.5095	5.0203	0.3753	25.1674	61.8882	0.0642	0.0985
GP-01004x GP-04026	5.4795	3.4541	0.2618	35.363	54.2463	0.0751	0.1628
GP-01004x Entry-23	6.8521	3.67	0.2135	20.73	67.8152	0.1148	0.1102
GP-01004x Entry P-S-2	5.8558	1.9563	0.2178	39.7321	51.3652	0.0917	0.1497
GP-01005x GP-01009	5.4077	3.0269	0.2896	32.8015	57.3424	0.0709	0.0010
GP-01005x GP-04026	6.293	3.9712	0.2833	24.0317	64.4185	0.079	0.1218

GP-01005x Entry-23	6.6211	3.7264	0.2925	25.9668	62.4511	0.0535	0.0805
GP-01005x Entry P-S-2	6.2656	4.623	0.3019	26.1454	61.0895	0.2033	0.2124
GP-01009x GP-04026	5.8085	3.3758	0.2916	41.6559	47.8395	0.1797	0.2491
GP-01009x Entry-23	5.0227	2.4532	0.2093	35.9909	55.4332	0.07	0.1583
GP-01009x Entry P-S-2	4.9687	3.3028	0.3448	58.5712	31.3926	0.1067	0.1673
GP-04026x Entry-23	6.882	3.6665	0.3022	40.1891	47.7305	0.1157	0.135
GP-04026x Entry P-S-2	6.0189	4.3524	0.2563	32.776	55.4772	0.1489	0.1313
Entry-23x Entry P-S-2	5.7706	4.4571	0.2777	26.5717	61.9086	0.1987	0.1626
Mean	5.87	3.71	0.27	35.18	53.92	0.10	0.14
Standard Deviation	0.63	0.73	0.05	10.94	10.57	0.04	0.05
CV	10.71	19.66	16.92	31.10	19.60	45.93	36.40
Minimum	4.58	1.96	0.20	15.85	31.39	0.01	0.01
Maximum	6.88	5.17	0.39	58.57	73.76	0.20	0.25

Linoleic Acid

In traditional sunflower oil, the linoleic acid content will be generally very high (60-70%). Linoleic acid and its derivative fatty acids are essential fatty acids and not synthesized by human being and hence, must be obtained from dietary sources. High level of linoleic acids in the oil reduces the blood cholesterol level and plays an important role in preventing atherosclerosis [11]. Thus, edible oil with high linoleic acid content is premium oil. According to results of this study Entry no-20 had highest linoleic acid (69.89%) among the studied inbreds which can be used for genetic analysis and breeding programs. Among 31 inbreds line linoleic acid ranges from 18.37-69.89. Others inbred GP-01005 (67.81%), GP-04017 (67.40%) and GP-04012 (67.34%) also contain high percent of linoleic acid which can be utilized in quality breeding to develop healthy sunflower oil. In crossing generation of selected line linoleic acid ranges 31.39-73.76%. Among derived crosses, the highest proportion of linoleic acid recorded in combination GP-01004x GP-01005 (73.76%), GP-01004x Entry-23 (67.81%), BHAC-04038(1) x Entry-23 (65.84%) and GP-01005x GP-04026 (64.42%) compare to their respective parents. Whereas involving parents GP-04026, BHAC-04038(1), Entry-23, GP-01005 and GP-01004 contain 66.22%, 63.87%, 55.99%, 67.82% and 46.72% respectively (Tables 2 & 3). Kostik and Bauer [9] reported 52-67 percent, Rosa et al. [12] 62-69%, Praveen (2015) 24.63-84.97%, Skoric (2015) 2.6-87.1% linoleic acid in their study. Onemli [3], Praveen [4] conclude linolenic acid varied significantly in sunflower germplasm.

Linolenic Acid

It is worthy to note that linolenic acid is also an essential fatty acid; however, its presence in the oil may causes rancidity and off-flavor. In traditional sunflower oil, the linolenic acid content will be generally <1 percent. As like as linoleic acid, linolenic acid and its derivative fatty acids are essential fatty acids and not synthesized by human being and hence, must be obtained from dietary sources. In this study the inbred Entry no-22 and GP-04019 had highest linolenic acid 0.4276% and 0.4234% among the studied lines

which can be used for genetic analysis and breeding programs. Others inbred GP-04017 (0.3181%), GP-01009 (0.2323), GP-04026 (0.1585%), GP-04018 (0.1576%), GP-04028 (0.1480%) and GP-04024 (0.1447%) also contain high percent of linolenic acid which can be utilized in quality breeding to develop healthy sunflower oil. In selected lines it ranges 0.06-0.23. In F1 obtain from selected parents it ranges 0.01-0.02%. Among derived crosses, the highest proportion of linolenic acid recorded in combination GP-01005x Entry P-S-2 (0.20%), Entry-23x Entry P-S-2 (0.20%), GP-01009x GP-04026 (0.18%) and GP-04026x Entry P-S-2 (0.15%) respectively. Whereas involving parents GP-04026, GP-01009, Entry-23, Entry P-S-2 and GP-01005 contain 0.0591%, 0.0668%, 0.0987%, 0.2323% and 0.1585% respectively (Table 3). Onemli [3], Praveen [4] reported significant variation for linolenic (C18:3) acid in their study.

Cis-ecosenoic Acid

Cis-ecosenoic acid is also unsaturated fatty acid which found in sunflower genotype <1 percent. Onemli [3], Praveen [4] reported significant variation for cis-ecosenoic acids (C20:1) in their study. In parental line in this study its range is 0.0004- 1.00 percent. The genotype entry no-21(1.00%) and Entry no-22(1.00%) contain the highest percentages of cis-ecosenoic acid in parental inbred. Selected germplasm it ranges 0.001-0.79 percent. The selected inbred GP-04026 (0.79%) contain the highest proportion of cis-ecosenoic acid. In derived crosses it ranges 0.01-0.25%. The highest proportion of cis-ecosenoic acid found in the cross combination GP-01009x GP-04026 (0.25%), BHAC-04038(1)x Entry P-S-2 (0.2320%), Entry no.-20x GP-01009 (0.2205%) and GP-01005x Entry P-S-2 (0.2124%) respectively [13-21].

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