Pak. j. sci. ind. res., vol. 33, no. 9, September 1990

FATTY ACID COMPOSITION OF INDIVIDUAL LIPID FRACTIONS IN COTYLEDONS AND PRIMARY ROOTS OF *ZEA MAYS* (NEELUM)

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(Received November 7, 1989; revised October 11, 1990)

An investigation was conducted to study the variation in the fatty acid composition of the individual lipid fractions in *Zea mays* variety Neelum, cotyledons and primary roots during germination to various root length. Fatty acid composition of the lipid of cotyledons did not show much variations during germination as compared to the resting seeds. In the polar lipid fractions saturated fatty acids were higher than in the neutral lipids. In the primary roots, however unsaturated acids including the $C_{18:2}$ decreased. The quantities of the fatty acids were essentially lower than in cotyledons.

Key words : Fatty acid, Roots, *Zea mays*, Cotyledons, Primary roots.

Introduction

Many studies have been conducted in different oil seeds during germination [1-10]. Several workers have also studied the lipid composition of the corn from different aspects [11-29]. But detailed study about the composition of various lipid functions has not been done. Therefore, the present study was conducted to look into the qualitative and quantitative aspects of maize seed lipids during resting and germinating stages.

Materials and Methods

Germination of maize seeds. Corn seeds of variety Neelum were obtained from the Maize Research Institute, Yusufwala, District Sahiwal. The seeds were washed with tap water. Some of the washed seeds were used as resting seed samples, while the rest of the seeds were germinated at 30° between the folds of moist filter paper in the dark in an incubator. As germination started after 24 hr seeds were sampled at various stages of germination i.e. at 5, 10, 15, 20, 25 and 30 mm root length.

Lipid extraction. The cotyledons were ground in a pestle and mortar and were then homogenized in 20 volumes (ml/g) chloroform: methanol (2:1) in a top drive homogenizer for 5 min. and filtered through a filter paper. Three more washing were similarly carried out. The non lipids were removed by the Folch washing method [30]. After drying the solvent in a rotary evaporator the weights of the lipids were determined and their percentages were thus calculated on a dry weight basis.

The resting seeds were similarly treated. However, the grinding of the primary roots was carried out with 2g of sand, which had been washed in alkali/acid/distilled water, and subjected to lipid extraction as above.

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Thin layer chromatography and location of individual lipids. 5µl of a 10% solution of the lipid sample in chloroform was applied to freshly activated thin layer chromatography (TLC) plate coated with 0.3 mm thick layer of silica gel G. (E. Merck Darmstadt, West Germany). For polar and neutral lipids the solvent systems used were chloroform/methanol/30% ammonia/water (60:35:5:2.5) and petroleum ether/diethyl ether/acetic acid (80:20:2) respectively. Various lipid fractions were identified by spraying reagents [31] and by co-chromatographing of the authentic samples and published data [32,33].

Preparative TLC. For quantitative determination of lipid classes, 5 mg of the lipid (50 µl of a 10% solution) was applied in the form of a 10 cm long band on a 0.5 mm freshly activated TLC plate. After development, the bands were located by spraying with a 0.2% 2,6-dichlorofluorescein and viewing under ultra-violet light. The bands were then scrapped off the plates and stored in the refrigerator for gas chromatography (GC).

Gas chromatography . Methyl esters of the fatty acids were prepared by treatment of the lipids with boron/trifluoride/methanol according to the procedure described for individual type of lipid by Morrison *et al.* [34]. A known amount of $C_{17:0}$ as internal standard was added to each sample. 1.0 - 1.5 µl of the ether extract of the sample was then injected in a Pye Unicam 204 GC (W.G. Pye and Co. Ltd. Cambridge, England) fitted with a flame ionization detector and 1.5 x 3 mm glass column packed with 10% DEGS on 80/100 mesh chromosorb WAW (Supel Co., Inc., Bellefonte, PA). The column temperature was maintained at 200° with a nitrogen carrier gas with a flow rate of 40 ml/min. Total percentages of each of the lipid fractions, for both neutral and polar lipids, in the resting seeds, cotyledons and primary roots of 5, 10, 15, 20, 25 and 30 mm root length were calculated according to Akhtar *et al.* [35].

Preparative TLC and GC for determining the percentages of the various lipid classes were performed in duplicate.

Results and Discussion

Fatty acid composition of the resting seeds. Table 1 shows the fatty acid composition of the lipids of the resting seeds. $C_{18:2}$ was the most abundant fatty acid except in the triglycerides and polar lipid fractions, where C_{18} dominated. Stumpf *et al*. [36] also observed the same in soybean phosphoipids. $C_{18:2}$ of sterol ester, free fatty acid, 1:2 and 1:3 diglyceride and mono glyceride fractions were 32.98, 41.79, 24.53, 40.1 and 33.23% respectively. While in the triglycerides, phosphatidyl choline, lysophosphatidyl choline and phosphatidyl serine fractions, $C_{18:2}$ showed up in lesser quantity as compared to the other lipid fractions (Table 1). $C_{18:1}$ was the next major fraction, without much variation from $C_{18:2}$ percentages of the neutral lipids and the polar lipids. C_{18} which was the major fatty acid in the triglycerides and polar lipids was considerably reduced in the rest of the neutral lipids as compared to $C_{18:1}$ and $C_{18:2}$. This showed that the triglyceride represented the storage and that C_{18} was later desaturated to $C_{18:1}$ and $C_{18:2}$ Diepenbrock [37] showed the correlation between C_{18}, $C_{18:2}$ and $C_{18:3}$ in this studies upon *Brassica napusL.*

$C_{18:3}$ was absent in the sterol ester and in polar lipid fractions. It was low in triglycerides and free fatty acid fractions, but higher in 1:3 and 1:2 diglycerides and in mono glycerides, while in polar lipids it was present upto 2%. This most probably indicated that the break down of triglyceride fatty acid had not started as yet. The rest of the unsaturated fatty acid i.e. $C_{20:2}$, $C_{20:4}$ were present in less percentages in the resting seeds in both neutral and polar lipids.

In the resting seeds, the fatty acid composition of C_{16} did not show much variation in the lipid fractions, except that it was high in the neutral lipids and lower in percentage in the polar lipids as compared to C_{18} (Table-1). C_{14} was present in lesser quantities as compared to C_{16}, on the other hand C_{20} was present in the polar lipid fractions in larger percentage as compared to the neutral lipids. Increased levels of saturated fatty acids in the polar lipid fractions would facilitate the formation of cellular membrane during germination. $C_{20:2}$ was absent in the polar lipids as was $C_{18:3}$, however, $C_{20:2}$ was present in small percentages in neutral lipids, i.e. in the sterol ester fraction 1.94%, triglyceride 0.46%, free fatty acid 0.64%, 1:3 and 1:2 diglyceride fraction 1.65% and 1.86% respectively and in the monoglyceride fractions upto 4.07% whereas $C_{20:4}$ was only present in the triglyceride free fatty acid, monoglyceride and phosphatidyl choline lipid fractions, it was absent in the rest of the fractions. C_{24} was present in the polar lipids but in larger percentages than C_{22}, and there was not much variation in its percentages as compared to C_{22} in the rest of the lipid fractions. C_{10} and C_{12} fractions were present in trace amounts as compared to the other fatty acids and C_{10} fatty acid was absent in the monoglycerides fraction of the resting seeds. The accumulation of the long chain fatty acids indicated that these were to be utilized during fat metabolism [38].

Fatty acid composition of the lipid fractions of cotyledons during germination. Table 2 and 3 show the fatty acid composition of cotyledons of *Zea mays* variety Neelum during germination of the primary roots at 5 mm and 30 mm.

At all stages of germination (cotyledons of germinating seeds 5 mm to 30 mm root length) there was not much perceptible change in the fatty acid composition, except that the only addition to the existing lipid fraction was 6-0-acyl steryl glucoside, 6-0- acyl monogalactosyl diglyceride, phosphatidyl ethanolamine and lysophosphatidyl ethanol amine. These lipid fractions were absent in the resting seeds. These fractions had the same fatty acid pattern, except that in the 6-0-acyl-mono galactosyl diglyceride fraction $C_{16:2}$ and $C_{16:3}$ appeared

TABLE 1. PERCENTAGE OF FATTY ACID COMPOSITION OF LIPIDS OBTAINED FROM RESTING SEED OF *ZEA MAYS* (NEELUM).

Lipid class	C_{10}	C_{12}	C_{14}	C_{16}	C_{18}	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	C_{20}	$C_{20:2}$	$C_{20:4}$	C_{22}	C_{24}
Sterol ester	0.57	0.81	8.26	9.69	8.82	23.95	32.98	–	5.44	1.94	–	3.68	3.86
Triglyceride	0.29	0.32	3.31	6.99	48.3	14.6	20.23	0.61	2.85	0.46	0.76	0.56	0.69
Free fatty acid	0.32	0.54	6.69	6.69	9.66	24.2	41.79	0.89	2.36	0.64	1.6	0.66	0.96
1:3 diglyceride	0.20	0.69	9.31	10.49	9.49	22.02	28.53	8.29	–	1.65	9.33	–	–
1:2 diglyceride	0.59	0.79	8.49	9.69	9.59	24.0	40.1	4.89	–	1.86	–	–	–
Monoglyceride	–	0.54	7.26	9.5	9.84	23.06	33.23	6.2	–	4.07	6.3	–	–
Phosphatidyl-choline	0.46	0.52	9.12	11.12	32.26	13.04	17.2	–	6.32	–	2.67	2.12	5.17
Lysophosphatidyl-choline	0.44	0.50	10.0	12.10	32.18	13.45	17.2	–	6.28	–	–	2.57	5.28
Phosphatidyl-serine	0.48	0.55	10.63	12.53	28.16	13.82	17.44	–	7.79	–	–	2.57	5.93

TABLE 2. PERCENTAGE OF FATTY ACID COMPOSITION OF LIPIDS OBTAINED FROM COTYLEDONS OF *ZEA MAYS* (NEELUM) WHEN THE PRIMARY ROOT HAD GROWN TO 5 MM.

Lipid class	C_{10}	C_{12}	C_{14}	C_{16}	$C_{16:2}$	$C_{16:3}$	C_{18}	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	C_{20}	$C_{20:2}$	$C_{20:4}$	C_{22}	C_{24}
Sterol ester	0.46	0.72	8.66	10.72	–	–	8.88	23.76	30.81	1.0	5.58	1.92	–	3.64	3.85
Triglyceride	0.47	0.60	9.11	10.79	–	–	32.47	11.68	13.63	3.59	5.80	1.55	4.86	1.75	3.7
Free fatty acid	0.30	0.50	8.75	10.69	–	–	10.68	15.82	33.07	3.60	5.55	1.60	4.12	1.64	3.68
1:3 diglyceride	0.40	0.69	8.31	10.77	–	–	10.69	22.74	36.89	4.86	–	4.65	–	–	–
1:2 diglyceride	0.79	0.79	9.49	11.79	–	–	9.96	20.98	34.36	6.54	–	5.57	–	–	–
Monoglyceride	–	0.48	10.06	14.02	–	–	13.86	17.53	22.78	8.29	–	4.65	8.33	–	–
6-0-acylsteryl glucoside	0.84	1.12	13.17	17.02	–	–	15.77	–	31.52	3.63	7.49	3.39	6.05	–	–
6-0-galactosyl diglyceride	0.99	-	10.17	19.69	3.59	3.85	11.61	–	34.81	5.62	–	1.89	7.18	–	–
Phosphatidyl ethanolamine	0.18	0.55	10.77	11.49	–	–	26.92	11.24	17.29	–	7.27	0.37	6.58	2.19	5.15
Phosphatidyl choline	0.38	0.43	9.21	11.29	–	–	30.61	10.14	15.43	–	6.08	0.76	6.06	3.91	5.7
Lyso phosphatidyl-ethanolamine	0.73	0.85	10.29	15.76	–	–	27.09	12.23	17.24	–	7.34	–	–	2.88	5.59
Lysophosphatidyl choline	0.31	0.46	10.2	12.26	–	–	32.2	11.68	18.67	–	6.33	–	–	2.59	5.3
Phosphatidyl serine	0.38	0.47	10.69	12.69	–	–	30.47	11.87	18.04	–	7.82	–	–	2.59	4.98

TABLE 3. PERCENTAGE OF FATTY ACID COMPOSITION OF THE LIPIDS OBTAINED FROM COTYLEDONS OF *ZEA MAYS* (NEELUM) WHEN THE PRIMARY ROOT HAD GROWN TO 30 MM.

Lipid class	C_{10}	C_{12}	C_{14}	C_{16}	$C_{16:2}$	$C_{16:3}$	C_{18}	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	C_{20}	$C_{20:2}$	$C_{20:4}$	C_{22}	C_{24}
Sterol ester	0.26	0.36	9.88	11.95	–	–	10.19	14.47	34.92	2.54	7.0	0.95	–	3.64	3.84
Triglyceride	0.1	0.1	10.21	11.98	–	–	35.04	5.0	15.25	1.61	7.57	0.04	6.65	1.77	3.68
Free fatty acid	0.09	0.09	10.34	11.82	–	–	11.34	11.84	34.98	1.21	7.28	0.6	5.15	1.6	3.66
1:3 diglyceride	0.12	0.21	10.74	12.83	–	–	11.27	19.0	42.13	1.90	–	1.89	–	–	–
1:2 diglyceride	0.19	0.27	11.89	13.59	–	–	11.99	17.09	41.81	2.75	–	1.05	–	–	–
Monoglyceride	–	0.4	12.26	15.08	–	–	15.06	15.11	26.49	5.0	–	0.75	9.85	–	–
6-0-acylsteryl-glucoside	0.20	0.25	14.6	17.9	–	–	17.09	–	32.57	1.04	8.6	0.75	7.0	–	–
6-0-acylmonogalactosyl-diglyceride	0.07	–	11.72	20.62	4.27	4.9	12.45	–	36.89	0.47	–	0.22	8.39	–	–
Phosphatidyl ethanolamine	0.02	0.16	11.42	12.23	–	–	28.29	6.19	19.19	–	7.98	0.07	7.16	2.14	5.15
Phosphatidyl choline	0.02	0.09	10.21	12.03	–	–	31.64	5.06	17.91	–	6.77	0.03	6.7	3.9	5.64
Lyso phosphatidyl-ethanolamine	0.08	0.11	11.18	16.53	–	–	29.21	6.14	20.31	–	8.0	–	–	2.86	5.58
Lysophosphatidyl choline	0.02	0.08	10.99	12.99	–	–	34.19	6.29	20.66	–	6.92	–	–	2.56	5.3
Phosphatidyl serine	0.02	0.04	11.29	13.14	–	–	31.12	7.63	20.92	–	8.2	–	–	2.58	4.97

which increased with germination from 3.59% at 5 mm root length, to 4.27 and 4.9% at 30 mm root length respectively (Tables 2 and 3).

As in the resting seeds $C_{18:2}$ dominated in all the lipid fractions, except in the triglyceride and polar lipid fractions. At all stages of germination under study, it increased gradually in all the lipid fractions. El Nockrashy *et al*. [39] also observed that $C_{18:2}$ continuously increased in the cotton seeds. In the cotyledons, as germination progressed from 5 mm root length to 30 mm root length, the fatty acid present were $C_{18:2}$, $C_{18:3}$, C_{22}, C_{12} and C_{10} in the order of decreasing percentages, comparable with each other, in the neutral lipid fractions, while for triglyceride and polar lipid fractions C_{18} was the major fatty acid, followed in order of decreasing percentages by $C_{18:2}$, $C_{18:1}$, C_{16}, C_{14}, C_{20}, $C_{20:4}$, C_{24}, $C_{18:3}$, C_{22}, $C_{20:2}$, C_{12} and C_{10}. Weber [13] in his study upon corn kernel observed triglycerides having higher levels of C_{18}. With increasing germination the quantitities of C_{18}, C_{14}, C_{16}, $C_{18:2}$, C_{20}, $C_{20:4}$ increased while C_{10}, C_{12}, $C_{18:1}$, $C_{18:3}$ and $C_{20:2}$ decreased. Similar results were attained by Rakhmanov *et al*. [40] while studying the composition of cotton seed lipids, where $C_{18:3}$ decreased and $C_{18:1}$ and $C_{18:2}$ increased, when the seeds were soaked in $CuSO_4$ solution. However Negishi [41] in his study upon soybean cotyledons observed that while $C_{18:1}$ decreased C_{16} increased. For C_{22} and C_{24}, on the other hand, not much change occurred with increase in the root length, nevertheless there were higher quantities of saturated fatty acids in the polar lipids as compared to the neutral lipids, this would most probably be, because the higher quantities of phosphoglycerides are used in the formation of cellular membrane. Similar results

were shown by Dogras [42], Chernenko [43] and El- Nockrashy [39].

C_{10} was absent throughout germination in the monoglyceride fractions, while C_{12} was absent in 6-0-acylmonogalactosyl diglyceride. $C_{18:3}$ which was absent in the sterol ester of the resting seeds, appeared in the cotyledons and increased with germination. These results indicate that a close relationship exists between the metabolism of the sterol and the utilization of oil in the cotyledons and that sterol is a vital constituent of the plant. C_{20} was absent in the diglycerides, monoglycerides and in 6-0-acyl monoglyceride but was present to the extent of 7%, in the polar lipids and 5% in the rest of the neutral lipids at 5mm root length. $C_{20:2}$ was absent in the polar lipids, but was present in varying amounts in the neutral lipids (Tables 2 and3). $C_{20:4}$ was absent in diglyceride, sterol ester, lysophosphatidyl ethanol amine and phosphatidyl serine fractions. C_{22} was present in sterol ester, triglyceride, free fatty acid fractions and in all the polar lipid fraction but was absent in the rest of the neutral lipids, same as C_{24}, and there was not much change as germination progressed in both the glycolipids, $C_{18:1}$ was absent.

Fatty acid composition of the primary root lipid fractions during germination : Table 4 and 5 show the fatty acid composition of the primary root lipid fraction at 5 mm and 30 mm root length. The quantities of the fatty acids were essentially lower than those of the cotyledons. These results indicate that during germination the fatty acid utilization is a source of energy.

The most abundant fatty acid was found to be $C_{18:2}$ in all lipid fractions, even in triglycerides contrary to the cotyledons. $C_{18:2}$ gradually decreased in all the fractions with increase in root length. However in the polar lipids as in the case of cotyledons, C_{18} still dominated and also increased with germination. Weber [13] obtained similar results in his study of corn germ and endosperm. On the other hand C_{16} in the neutral lipids of the primary roots was higher than C_{18} which was contrary to that of the cotyledons, but it too increased with germination.

In the primary root, as germination progressed from 5 mm root length to 30 mm root length, the fatty acids present in the order of decreasing percentage as compared with each other were : $C_{18:2}$, C_{16}, C_{18}, $C_{18:1}$, C_{14}, C_{20}, $C_{20:4}$, C_{24}, $C_{18:3}$, C_{22}, $C_{20:2}$, C_{12} and C_{10} in all the neutral lipids except in the polar lipid fractions, where C_{18} was still the major fatty acid, as in the cotyledons followed by $C_{18:2}$ while the pattern of the rest of the fatty acid percentages comparable to each other remained the same as in the neutral lipids. The percentages of C_{18}, C_{14}, C_{16}, $C_{20:4}$, C_{20} increased with increase in the root length (Tables 4 and 5). While the percentages of C10, C_{12}, $C_{18:1}$, $C_{18:2}$, $C_{18:3}$, $C_{20:2}$ decreased during germination: C_{22} and C_{24} quantities remained almost constant. These results correspond with the earlier studies upon corn by the present authors [45]. Where it was reported that the quantity of the oil in the primary roots lesser than in the cotyledons; this is probably due to the quick utilization of the unsaturated fatty acids for germination and that long chain fatty acids are utilized at later stages of germination. As in the cotyledons, there were higher quantities of saturated fatty acids in the polar lipid fractions than in the neutral lipids. $C_{18:3}$ appeared in the sterol ester fraction as in the cotyledons and remained low through out germination, while $C_{20:4}$ in sterol ester fraction remained undetected as in the cotyledons. $C_{18:3}$ was absent in the polar lipids. C_{10} and C_{12} decreased with germination and C_{10} disappeared at 25mm root length in all the fractions, except the sterol esters, triglyceride, free fatty acid and 6-0- acyl monogalactosyl diglyceride, while C_{12} remained in infinitesimal quantities. $C_{20:4}$ disappeared in

TABLE 4. PERCENTAGE OF FATTY ACID COMPOSITION OF THE LIPIDS OBTAINED FROM PRIMARY ROOT OF *ZEA MAYS* (NEELUM) WHEN THE RADICLE HAD GROWN TO 5 MM.

Lipid class	C_{10}	C_{12}	C_{14}	C_{16}	$C_{16:2}$	$C_{16:3}$	C_{18}	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	C_{20}	$C_{20:2}$	$C_{20:4}$	C_{22}	C_{24}
Sterol ester	0.22	0.5	4.84	22.38	–	–	17.61	17.88	24.0	1.12	4.69	1.75	–	2.15	2.86
Triglyceride	0.28	0.54	2.63	24.09	–	–	18.09	14.67	28.0	2.13	2.84	0.65	2.59	1.0	2.49
Free fatty acid	0.30	0.59	2.53	23.52	–	–	19.49	16.26	26.94	2.25	2.41	0.93	2.34	1.15	1.29
1:3 diglyceride	0.27	0.49	2.93	26.16	–	–	19.17	18.43	28.96	–	2.81	0.78	–	–	–
1:2 diglyceride	0.26	0.46	2.91	26.28	–	–	19.03	18.44	28.94	–	2.95	0.73	–	–	–
Monoglyceride	0.22	0.41	2.92	27.4	–	–	19.12	15.6	28.37	–	2.64	0.79	2.53	–	–
6-0-acylsteryl glucoside	0.20	0.41	4.51	19.02	–	–	29.13	–	23.24	6.32	7.97	2.23	6.97	–	–
6-0-acylmonogalactosyl-diglyceride	0.20	0.36	12.14	16.0	1.0	1.19	27.18	–	24.73	7.59	–	2.0	7.61	–	–
Phosphatidyl ethanolamine	0.25	0.51	4.81	19.41	–	–	29.22	13.93	25.43	–	2.44	0.75	–	1.1	2.15
Phosphatidyl choline	0.29	0.58	4.86	19.46	–	–	30.08	12.76	25.33	–	2.34	0.85	–	1.2	2.25
Lysophosphatidyl-ethanolamine	0.12	0.44	4.26	19.0	–	–	29.67	18.76	23.14	–	2.2	–	–	1.16	1.25
Lysophosphatidyl holine	0.20	0.41	4.73	19.32	–	–	29.05	15.7	25.2	–	2.15	–	–	1.19	2.05
Phosphatidyl serine	0.20	0.36	4.14	19.0	–	–	29.18	17.59	24.23	–	2.0	–	–	1.15	2.15

TABLE 5. PERCENTAGE OF FATTY ACID COMPOSITION OF THE LIPIDS OBTAINED FROM PRIMARY ROOT OF *ZEA MAYS* (NEELUM) WHEN THE RADICLE HAD GROWN TO 30 MM.

Lipid class	C_{10}	C_{12}	C_{14}	C_{16}	$C_{16:2}$	$C_{16:3}$	C_{18}	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	C_{20}	$C_{20:2}$	$C_{20:4}$	C_{22}	C_{24}
Sterol ester	0.05	0.05	8.83	24.14	–	–	23.13	8.12	22.08	2.4	5.21	1.0	–	2.14	2.85
Triglyceride	0.02	0.02	3.94	25.65	–	–	22.88	11.43	26.08	1.11	3.3	0.05	3.0	0.05	2.47
Free fatty acid	0.02	0.08	3.44	25.55	–	–	26.35	10.54	24.34	1.24	3.1	0.08	3.0	1.0	1.26
1:3 diglyceride	–	0.10	3.88	27.45	–	–	23.61	14.33	26.99	–	3.54	0.1	–	–	–
1:2 diglyceride	–	0.02	3.99	28.4	–	–	24.33	12.63	27.00	–	3.58	0.05	–	–	–
Monoglyceride	–	0.02	3.99	28.56	–	–	24.52	9.85	26.09	–	3.84	0.03	3.1	–	–
6-0-acylsteryl glucoside	–	0.02	5.31	20.32	–	–	33.91	–	21.04	1.7	8.81	1.39	7.5	–	–
6-0-acylmonogalactosyl-diglyceride	0.11	0.21	13.8	17.66	1.3	1.46	31.4	–	23.1	1.61	–	1.22	8.13	–	–
Phosphatidyl ethanolamine	–	0.02	5.94	20.62	–	–	33.91	10.19	23.23	–	2.88	–	–	1.09	2.12
Phosphatidyl choline	–	0.06	5.86	20.82	–	–	34.04	9.91	23.87	–	3.01	–	–	1.1	1.25
Lyso phosphatidyl-ethanolamine	–	0.02	5.52	20.17	–	–	34.26	13.63	21.01	–	3.03	–	–	1.16	1.2
Lysophosphatidyl	–	0.02	5.99	20.66	–	–	33.79	10.14	23.19	–	2.92	–	–	1.15	2.14
Phosphatidyl serine	–	0.02	5.09	20.26	–	–	33.62	12.46	22.49	–	2.82	–	–	1.1	2.14

the polar lipids of the primary root contrary to the cotyledons where it was present only in the phosphatidyl choline and ethanolamine fractions. The rest of the fatty acid composition remained almost the same as those of the cotyledons except for lower percentages of fatty acids and consequently lowered oil content [45].

It is thus clear that whereas in the cotyledons and the primary roots the changes in the fatty acid composition were not as significant as compared to the resting seeds, there was an increase in the percentages of saturated fatty acids while the relative amount of unsaturated fatty acids decreased. This suggested a preferential utilization of $C_{18:2}$, $C_{18:1}$, $C_{18:3}$, $C_{20:2}$ and $C_{20:4}$ in the primary roots. Results of changes in fatty acid content in the cotyledons and embryo of hazel seeds have been reported where $C_{18:2}$ decreased and was being utilized by the developing primary root [44]. However little data upon corn root has been cited in literature [11-21, 23-28].

The present study shows a detailed picture of *Zea mays*, variety Neelum, fatty acid composition of the individual lipid class fractions in the resting seeds, cotyledons and primary roots upon germination from 5 mm till 30 mm root length. Though some authors [11-29] have collected data relating to *Zea mays*, they have dealt only with specific aspects of lipid analysis and have not given a complete picture of the variation in the fatty acid compositions of every lipid fraction in the cotyledons and their corresponding roots. These studies will therefore be of immense importance not only for academic record but also would help boost yields from the oil crop, thus achieving self sufficiency in the national edible oil out put.

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