Research Article

Agro-management effects on fatty acid composition of Sesame (*Sesamum indicum* L.)

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Abstract

The fatty acid composition was evaluated in field grown sesame cultivars (*Sesamum indicum* L.) at New Developmental Farm Agriculture University, Peshawar, KPK Pakistan during summer 2012. The experiment was laid out in RCBD with split plot arrangement having four replications each. Two sesame cultivars *viz.*, local black and local white were sown at different dates i.e. 20th June, 10th and 30th July, and supplied with various nitrogen levels @ 0, 40, 80 and 120 kg ha^{-1}. Results deciphered that sowing dates had significantly affect all the parameters except oil content. Crop grown on 20th June had significantly maximum palmitic acid (8.9%), elaidic acid (0.07%), linoleic acid (40%) and octadecadienoic acid (4.1%) while crop sown on 30th July produced maximum stearic acid (4.4%) and oleic acid (42.6%). Local white cultivar had significantly more palmitic acid (8%), elaidic acid (0.06%) and linoleic acid (38.7%) while less oil contents (45%), stearic acid (3%) and oleic acid (39.6%). Nitrogen application had also significantly affected all mentioned parameters. Plots treated with 120 kg N ha^{-1} produced maximum oil contents (52%), palmitic acid (10%), stearic acid (4.3%), oleic acid (43.2%), elaidic acid (0.07%), linoleic acid (40.5%) and octadecadienoic acid (4%) as compared to their control plots. The interaction between sowing dates, nitrogen levels and sesame cultivars indicated that crop sown on 20th June with local white cultivar and treated with 120 kg N ha^{-1} had significantly maximum oil content, palmitic acid, linoleic acid and octadecadienoic acid, but its stearic acid and oleic acid was significantly higher when crop sown on 30th July with local black cultivar. It was observed that local white cultivar sown on 20th June treated with 120 kg N ha^{-1} produced maximum oil contents and fatty acid composition.

Key words: Sesame (*Sesamum indicum* L.); sowing dates; nitrogen level; sesame cultivars; fatty acid composition

Introduction

Sesame (*Sesamum indicum* L.) belongs to family Pedaliaceae. Sesame is an important edible oilseed crop. It has wide variety of uses and there are well-developed domestic and international markets for its seed. The chemical composition of sesame shows that the seed is an important source of oil (44-58%), protein (18-25%), carbohydrate (13.5%) and ash (5%). The seed contains all essential amino acids and fatty acids. It is a good source of vitamins and minerals such as calcium and phosphorous [1]. The crop has high content of both excellent quality edible oil which shows high degrees of stability and resistant to oxidative rancidity due to the presence of endogenous antioxidants such as sesamol, sesamolinol and sesaminol [2].

In Pakistan, sesame was cultivated on an area of 77.6 thousand hectares with an annual production of 31 thousand tones and an average yield of 401 kg ha^{-1}, whereas in Khyber Pakhtunkhwa its average yield was 1000 kg ha^{-1} [3]. In general, sesame oil contains about 47% oleic acid (C18:1), 39% linoleic acid (C18:2), 9.0% palmitic acid (C16:0), 4.1% stearic acid (C18:0), and 0.7% arachidic acid (C20:0) [4]. However, a fatty acid composition as well as oil content is influenced by various physiological, ecological and cultural factors. Sowing date also influenced fatty acid composition of sesame by decreasing linoleic and increasing oleic and stearic acid content as sowing was delayed [5]. Moreover, the maturity of sesame seeds also causes fatty acid changes. Not only these conditions affect fatty acid composition but also genotypic factors play an important role in the process, resulting in the fact that each genotype shows different fatty acid composition [6]. Adequate supply of nitrogen is beneficial both for carbohydrates and protein metabolism. In sesame culture, chemical fertilizers, particularly nitrogen (N), are one of the greatest production inputs. Synthesis of fat requires both nitrogen and carbon skeletons during the course of seed development. The fatty acid composition of seed oil crops is mainly under genetic control, but can affect to some extent by nitrogen. Nitrogen plays the most important role in building the protein structure. Early in development, N deficiency is associated with elevated levels of ethylene, suggesting ethylene production in response to N-deficiency stress. Research in this area has resulted decreased levels of undesirable long-chain fatty acids. Another beneficial change in fatty acid composition would be an increase in the linoleic and oleic acid contents [7]. Therefore, the aims of this experiment were to find out the effect of sowing dates and nitrogen levels on fatty acid composition of sesame cultivars at the agro-climatic condition of Peshawar.

Materials and Methods

This research was conducted at New Developmental Farm of The University of Agriculture, Peshawar, (34° 00' N, 71° 30' E, 510 MASL) KPK Pakistan during summer 2012. The experiment was carried out in RCBD with split plot arrangement having four replications each. Sowing dates and sesame cultivars were allotted to main plots, while nitrogen levels were allotted to sub plots. A subplot size of 2.4 x 3 m was be used. Each sub plot was consisted of 6 rows having 40 cm row-to-row distance. Phosphorus as P_2O_5 was applied @ 60 kg ha^{-1} whereas half of nitrogen was applied at the time of sowing and remaining half was applied before flowering. Seed were sown at rate of @ 4 kg ha^{-1} and agronomic practices were carried out uniformly for all the experimental units throughout the growing season. Seed oil content (%) was determined by using Soxhlet apparatus and n-hexane (60ºC) as an extraction solvent according to [8]. Oil samples were stored in brown bottles at -30°C until analysis. Fatty acid composition of seed was determined with a Hewlett-Packard 6890 Series II gas chromatograph (Palo Alto, CA) equipped with a 15% OV-275 on Chromosorb PAW11/120 stainless steel column (6.1 m × 2 mm i.d.). Fatty acid methyl esters were prepared according to AOAC Method No. 963.33 [9]. The column temperature was 215°C; injector and detector temperatures were 250°C. The carrier gas was nitrogen, with a flow rate of 9.5 mL/min. Fatty acid were identified by retention time relative to authentic standards.

Heptadecanoic acid was used as an internal standard. Data collected were analyzed statistically according to the procedure relevant to RCB design. Upon significant F-Test, least significance difference (LSD) test was used for mean comparison to identify the significant components of the treatment means **[10]**.

Results and Discussion

Seed oil contents (%)

Analysis of data presented in Table 2 revealed that sesame cultivars and nitrogen levels had significantly affected oil contents, while sowing dates had non-significant influence. Plots treated with 120 kg N ha^{-1} produced maximum oil content (52%) while minimum oil contents (40%) was recorded in control plots. Similar results were reported by **[11, 12]** and **[1]** the increase in seed oil content by increasing nitrogen fertilizer rate may be due to the role of nitrogen in transform metabolic products to amino acid then protein and increase rate of fatty acid synthesis. Local black cultivar produced maximum (47%) oil content as compared to local white cultivar (45%). Interaction between D x V x N indicated in (Fig. 7) that both cultivars sown on 20^{th} June oil content increased with increase in nitrogen levels. However, when the sowing was delayed to 30^{th} July the response of nitrogen application was as effective as seen on 20^{th} June and oil content remain almost similar in all sowing dates.

Palmitic acid

Mean values of sowing dates (Table 2) indicated that crop sown on 20^{th} June produced maximum palmitic acid (8.9%) while minimum (6.3%) was obtained when crop sown on 30^{th} July. These results are in conformity with the findings of **[5]** who recorded highest palmitic acid percentage in early sowing mid-June as compared to late sowing mid-July. Local white cultivar produced maximum (8%) palmitic acid as compared to local black cultivar produced (7.1%). This must be due to difference in genetic constitution of sesame cultivars. Plots treated with 120 kg N ha^{-1} produced maximum (10%) palmitic acid while minimum (5.2%) plamitic acid was recoded in control plots. These results are in line with **[13]** found that when sesame treated with 160 kg N ha^{-1}, palmitic acid was significantly increase by raising nitrogen rates. Interaction between D x V x N indicated in (Fig. 1) that both cultivars produced maximum palmitic acid when sown on 20^{th} June. Palmitic acid increase with increase nitrogen levels. Early sown crop had maximum palmitic acid even when nitrogen was not added as compared with other sowing dates.

Stearic acid and oleic acid

Data on stearic acid and oleic acid (Table 2) indicated that crop sown on 30^{th} July produced maximum stearic acid (4.4%) and oleic acid (42.6%) while minimum stearic acid (2.6%) and oleic acid (38.2%) were recorded when crop was sown on 20^{th} June. These results are in agreement with the findings of **[5]** and **[14]** who recorded that increasing stearic acid and oleic acid content as sowing was delayed while in early sowing stearic acid and oleic acid percentage was lower as compared to late sowing due to high mean temperature. Local black cultivar produced maximum stearic acid (3.8%) and oleic acid (40.9%) as compared to local white cultivar produced (3%) stearic acid and (39.6%) oleic acid. Plots treated with 120 kg N ha^{-1} produced maximum stearic acid (4.3%) and oleic acid (43.2%) while minimum stearic acid (2.2%) and oleic acid (37%) were recorded in control plots. These results are also in line with **[13]** who reported that fatty acid composition of sesame oil is mainly under genetic control, but can be modified to some extent by nitrogen; they found that 160 kg N ha^{-1} to sesame had highest, stearic acid and

Table-1. Temperature (^{0}C), rainfall (mm) and relative humidity (%) of experimental site for the growing period of the sesame crop (June-October 2012)

Month	Mean temperature (C°)		Mean rainfall (mm)	R.H (%)
	Minimum	Maximum		
June	22	43	0	35
July	27	41	80	56
August	26	38	100	59
September	23	35	0	70
October	15	31	56	56

Table-2. Percent (%) palmitic acid, stearic acid, oleic acid, elaidic acid, linoleic acid, octadecadienoic acid and arachidic acid of sesame cultivars as affected by sowing dates and nitrogen levels.

Treatment	Oil contents (%)	PalmiticAcid	Stearic Acid	Oleic Acid	Elaidic Acid	Linoleic Acid	Octadecadienoic Acid
Sowing dates (D)							
20th June	46	8.9a	2.6c	38.2c	0.07a	40.0a	4.1a
10th July	45	7.5b	3.3b	39.9b	0.05b	37.8b	3.1b
30th July	45	6.3c	4.4a	42.6a	0.4c	37.0c	2.2c
LSD (0.05)	ns	0.19	0.005	0.02	0.005	0.02	0.04
Sesame cultivars (V)							
Local White	45 b	8.0a	3.0b	39.6b	0.06a	38.7a	3.1
Local Black	47 a	7.1b	3.8a	40.9a	0.05b	37.8b	3.0
Nitrogen (kg ha^{-1}) (N)							
0	40 d	5.2d	2.2d	37.0d	0.04d	35.8d	2.3d
40	44 c	6.9c	3.2c	39.2c	0.05c	37.3c	2.9c
80	48 b	8.1b	4.0b	41.7b	0.06b	39.3b	3.4b
120	52 a	10a	4.3a	43.2a	0.07a	40.5a	4.0a
LSD (0.05)	0.06	0.21	0.005	0.02	0.006	0.02	0.05
Interaction							
D x V	ns	ns	ns	ns	ns	ns	ns
D x N	ns	ns	ns	ns	*	ns	ns
N x V	ns	ns	ns	ns	ns	ns	ns
D x V x N	*	*	*	*	ns	*	*

Means in the same category followed by different letters are significantly different at $P \leq 0.05$ levels. ns = non-significant

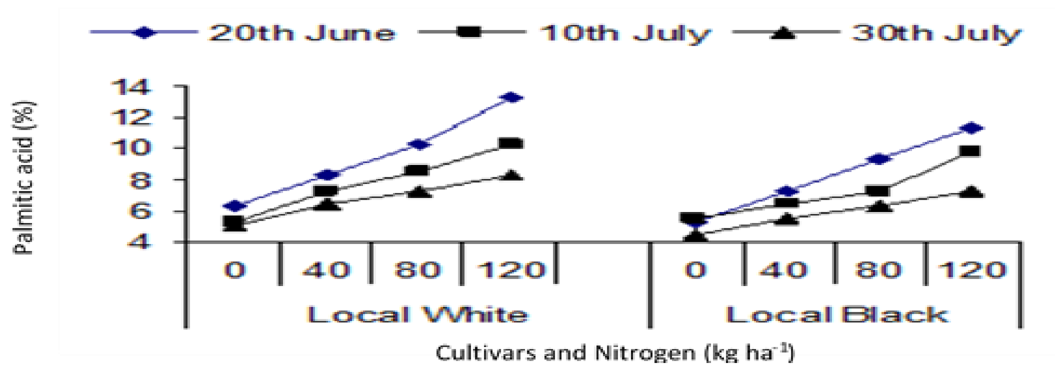
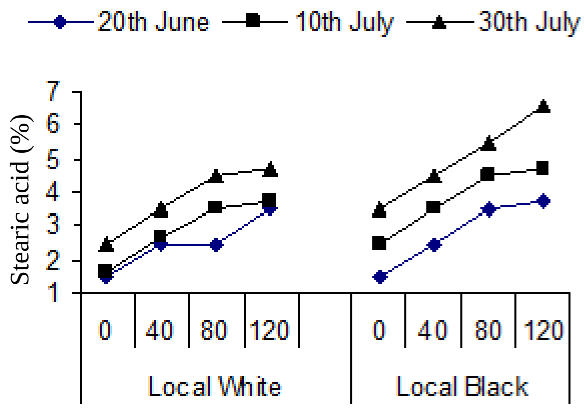
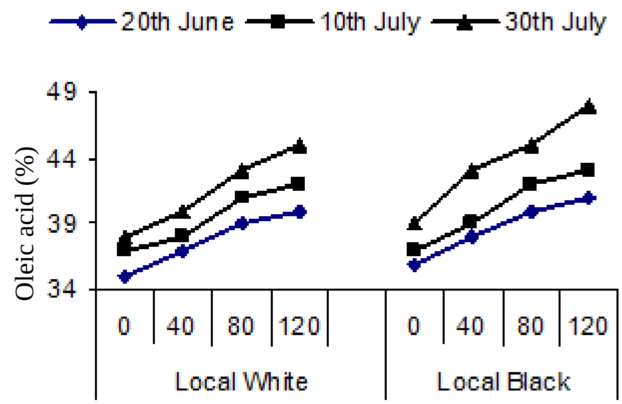


Fig. 1. Plamitic acid is affected by sowing dates, cultivars and N levels



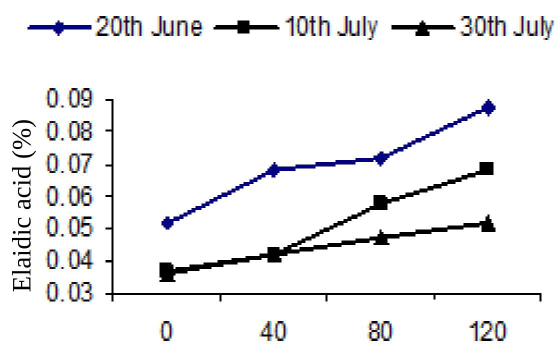
Cultivars and Nitrogen (kg ha^{-1})

Fig. 2. Stearic acid is affected by sowing dates, cultivars and N levels



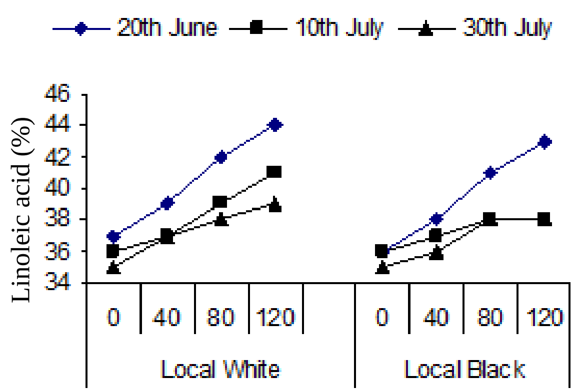
Cultivars and Nitrogen (kg ha^{-1})

Fig. 3. Oleic acid is affected by sowing dates, cultivars and N levels



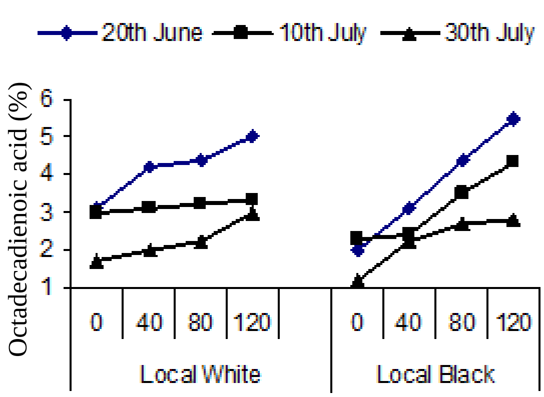
Cultivars and Nitrogen (kg ha^{-1})

Fig. 4. Elaidic acid is affected by sowing dates, cultivars and N levels



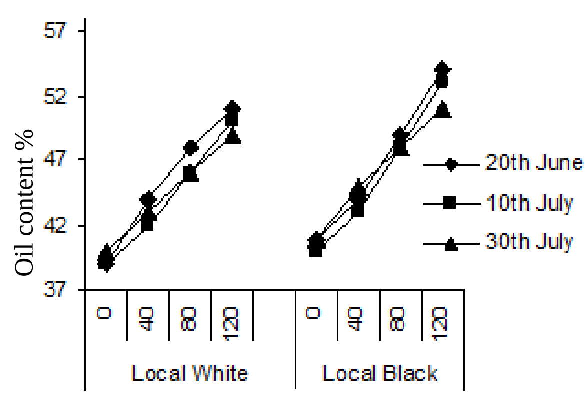
Cultivars and Nitrogen (kg ha^{-1})

Fig. 5. Linoleic acid is affected by sowing dates, cultivars and N levels



Cultivars and Nitrogen (kg ha^{-1})

Fig. 6. Octadecadienoic acid is affected by sowing dates, cultivars and N levels



Cultivars and Nitrogen (kg ha^{-1})

Fig. 7. Oil content is affected by sowing dates, cultivars and N levels

oleic acid content. In case of D x V x N interaction revealed in (Fig. 2 & 3) that both cultivars produced maximum stearic acid and oleic acid when sown on 30th July. Stearic acid and oleic acid increase with increase nitrogen levels. Late sown crop had maximum stearic acid and oleic acid even when nitrogen was not added as compared with other sowing dates.

Elaidic acid

Mean values of elaidic acid (Table 2) showed that maximum elaidic acid (0.07%) was recorded when crop was sown on 20th June while minimum (0.04%) was produced when crop sown on 30th July. Gupta et al. [5] also recorded highest elaidic acid percentage in early sowing mid-June as compared to late sowing mid-July delay sowing the elaidic acid % drastically decreases. Plots treated with 120 kg N ha^{-1} produced maximum elaidic acid (0.07%) while minimum (0.04%) was recorded in control plots. Similar results were reported by [13] who recorded that crop treated with 0-160 kg N ha^{-1}, elaidic acid was significantly effect by raising nitrogen level. Plots receiving more nitrogen increase elaidic acid percentage. In case of D x N interaction showed in (Fig. 4) that crop planted on 20th June had a very good response to nitrogen application and produced maximum elaidic acid (0.09%) when compared to control plots and other sowing dates.

Linoleic acid

Table 2 showed that linoleic acid significantly reduced with delay in sowing. Plots sown on 20th June had significantly higher linoleic acid (40%) while minimum (37%) was recorded for 30th July sowing. These results are in line with those of [5] who reported highest linoleic acid percentage in early sowing mid-June as compared to late sowing mid-July while delay sowing deictically decease in linoleic acid percentage occur. Plots supplied with nitrogen had significantly higher linoleic acid as compared to control plots. With increase nitrogen level linoleic acid increase significantly and therefore the highest level of nitrogen (120 kg ha^{-1}) produced maximum linoleic acid (40.5%) while minimum is recorded in control plot (35.8%). These results are inline with [14] who found that fatty acid composition of sesame oil is mainly under genetic control, but can be modified to some extent by N application, when sesame was treated with 160 kg N ha^{-1}, linoleic acid content was recorded highest at the intermediate 120 kg N ha^{-1}. Interaction between D x V x N indicated in (Fig. 5) that both cultivars produced maximum linoleic acid when sown on 20th June. Linoleic acid increases with increase in nitrogen levels. Early sown crop had maximum linoleic acid (44%) even when nitrogen was not added as compared with other sowing dates.

Octadecadienoic acid

Mean value of sowing dates (Table 2) showed that octadecadienoic acid significantly reduced with delay in sowing. Plots sown on 20th June had significantly higher octadecadienoic acid (4.1%) while lowest (2.2%) was recorded for 30th July sowing. Gupta et al. [5] also reported a significant effect of early sowing on octadecadienoic acid percentage increase as compared to late sowing. Plots supplied with nitrogen had significantly higher octadecadienoic acid as compared to control plots. With increase in nitrogen level up to (120 kg ha^{-1}) produced maximum octadecadienoic acid (4%) while minimum is recorded in control plot (2.3%). These results are in line with [10] who reported significant increase in octadecadienoic acid percentage occurs with an increase in the nitrogen level. The interaction among D x V x N showed in (Fig. 6) that both cultivars produced maximum octadecadienoic acid when sown on 20th June. Octadecadienoic acid increase with increase nitrogen levels. Early sown crop had maximum (5.5%) octadecadienoic acid even when nitrogen was not added as compared with other sowing dates.

Conclusion

It was concluded that cultivar local white sown on 20th June with nitrogen @ 120 kg ha^{-1} produced higher seed oil content (%), palmitic acid, elaidic acid, oleic acid, linoleic acid, octadecadienoic acid and arachidic acid. Therefore, local white cultivar of sesame sown around 20th June with nitrogen @ 120 kg ha^{-1} may give higher oil contents (%) and better fatty acids composition in Peshawar valley.

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