Korean J. Crop Sci. 51(1): 73~80(2006)

Influence of Drought Stress on Chemical Composition of Sesame Seed

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ABSTRACT : Sesame (*Sesamum indicum* L.) seeds contain abundant oil and antioxidative lignans related to the seed quality. To evaluate the potential effects of drought stress on the chemical composition of sesame seeds, eighteen cultivars were imposed water-deficit condition by withholding irrigation during 15 days at podding and maturing stage, compared with well-watered plants as control in seed yield and chemical composition. Drought treatments showed great decrease of seed yield with not affecting seed weight. The contents of sesamin and sesamolin decreased while lignan glycosides inversely increased in response to drought stress. Oil content was not significantly changed by drought treatment in spite of its slight decrease. In case of fatty acid composition, there were significant differences in increase of oleic acid while inverse decrease of linoleic acid under drought stress condition. These results demonstrate that the chemical composition of sesame seed may be modified with drought stress. In particular, the increase of sesaminol glucosides with strong antioxidative activity was observed.

***Keywords*:** sesame (*Sesamum indicum* L.), seed quality, drought stress, lignan glycoside, lignan, oil, fatty acid composition

Sesame (*Sesamum indicum* L.) is one of the most important oil crops and it has been remarkably used as a traditional health food in Korea. The sesame oil and seeds have excellent nutritional value (McKevith, 2005) and are mainly used for the commercial products. An advantage of both sesame seed and oil is their resistance to oxidative deterioration resulting in oxidative stability during storage and processing (Fukuda *et al.*, 1985; Fukuda *et al.*, 1986). Sesame seed contains a number of antioxidants including lipid-soluble lignans such as sesamin and sesamolin, and water-soluble lignan glycosides such as sesaminol triglucoside and sesaminol diglucoside (Katsuzaki *et al.*, 1994; Moazzami *et al.*, 2006). Sesame oil, consisting of approximately 50% seed weight, is mainly composed of fatty acids, palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2) and linolenic (18:3) acids (Kim *et al.*, 2004). The major components in sesame oil are unsaturated fatty acids (mainly oleic and linoleic acid), which contribute significantly to human nutrition (Were *et al.*, 2006). The quality of sesame seed and oil was related to the antioxidative lignans content and fatty acid composition. The phytochemical quality of sesame should be evaluated by the determination of bioactive compounds like lignan and fatty acid composition, in addition to the seed weight and oil yield.

It is generally known that phytochemicals contents can be altered in response to the stimulation and restriction of primary metabolite production, although the extent of any phytochemical change is not fully understood. Many classes of phytochemicals are influenced by environmental factors, such as water and temperature stresses (Kirakosyan *et al.*, 2004; Abreu & Mazzafera, 2005). There are many reports that drought stress affects chemical composition in several plants such as chickpea seeds (Behboudian *et al.*, 2001), St. John's wort leaves and flowers (Gray *et al.*, 2003), lupine seeds (Carvalho *et al.*, 2004; Carvalho *et al.*, 2005), Olive oil (Romero *et al.*, 2002), sugar beet root (Bloch *et al.*, 2006), rapeseed (Champolivier & Merrien, 1996) and soybean seeds (Britz & Kremer, 2002). Lack of water during vegetative or reproductive growth stages would be the limiting factors for seed growth, while it could be a way to enhance levels of secondary metabolites such as antioxidative lignans in sesame seeds. However, there is little information available regarding the effects of environmental stress on the production of high quality seeds in sesame. Although sesame cultivation was not greatly affected with drought condition during flowering and maturing stages, we hoped that drought treatment could be taken into consideration in order to improve the quality of sesame seeds, concerning on changes of seed chemical components such as lignans, lignan glycosides, oil, fatty acids.

The objectives of this study were to investigate the effect of drought stress on the seed chemical composition and seed yield in sesame cultivars.

MATERIALS AND METHODS

Plant materials and drought treatment

Eighteen cultivars of sesame, Korean recommended vari-

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eties, were used in this study and cultivars 'Ahnsan', 'Danbaeck', 'Hwangbaeck', 'Hanseom', 'Hansan', 'Jinbaeck', 'Nambaeck', 'Namda', 'Namsan', 'Pungan', 'Pungnam', 'Pungsan', 'Sunbaeck', 'Sungboon', 'Seodun', 'Suwon', 'Toobul' and 'Yangbaeck' were expressed as AS, DB, HB, HS, HSN, NB, JB, ND, NS, PA, PN, PS, SB, SBN, SD, SW, TB and YB, respectively. Sesame seeds were sown in pots (25 cm of diameter and 30 cm of depth) filled with the sandy soil, a mixture of soil, sand and compost (5 : 2 : 2, v/v/v) during normal growing seasons on June 15, 2004, and grown in the field of plastic rain shelter at Mokpo, a southern region of Korea. Three replicates per cultivar were tested with two plants per pot. The control plants were watered every one or two days with tap water. Flowering date of 18 cultivars was averaged in late July, and maturity date was in middle September.

Drought stress was induced for the half of the plants by withholding irrigation for 15 days between flowering and maturing stage (15 August - 30 August). After the drought treatment period, the plants were again watered and maintained to well-watered condition until seed harvest. The harvest was done at physiological maturity on October 10, 2004 after around 55 days the imposition of water stress.

The seeds harvested were cleaned and dried in the laboratory, and then stored in desiccators until gas liquid chromatography (GLC) and high performance liquid chromatography (HPLC) analyses. The weight of 200 random seeds of each line after drying at 60 °C for 6 hrs, was measured with a readability of 0.01 mg for calculating the seed weight and expressed as milligrams per seed. Seed yield per plant was the grams weight of total seeds from individual plant, and the seed weights from six plants were averaged in each experimental plot.

Chemical analyses of lignans, oil and fatty acid composition

About 2 g of each sample were homogenized using a homogenizer, extracted in 30 mL of n-hexane for 1 day with shaking at 100 rpm, and filtered. The residues were extracted two times more, and final volume of each extract solutions was exactly adjusted to 100 mL. The 50 mL of hexane extract was concentrated, dried for 6 hrs at 100 °C, and weighed and calculated for oil content. The hexane extract was used for lipid-soluble lignan analysis, while the residue (defatted sesame meal) after hexane extracting was stored at -20 °C for analysis of water-soluble lignan glycosides.

The 10 mL of hexane extract was exactly taken and completely vacuum-dried, and then 3 mL of methanol was added and shaken at warm condition (under 60 °C). Methanol extract was stored for 1 day at freezing room, and the supernatant was transferred to 2 mL autosampler bottle before HPLC injection for lignan analysis. The HPLC instrument (HPLC Agilent 1100 Series, Agilent Technologies Co., USA) equipped with an ultra-visible detector (Agilent 1100 Series Diode-Array Detector) at 290 nm and a reversed-phase column, Capcell Pak C18 UG 120 (5 μm, 4.6 × 150 cm, Shiseido Co., Japan) was used. The mobile phase was a mixture of methanol: water (75 : 25, v/v) as an isocratic condition and flow rate was set at 1.0 mL/min. Running time of each sample was within 20 min.

The defatted sesame meal (about 0.9 g) in 50 mL conical tube was extracted with 40 mL 80 % methanol/water for 1 day at room temperature by shaking at 150 rpm, and the supernatant was transferred to a 2 mL autosampler vial before HPLC injection for determination of lignan glycosides (sesaminol triglucoside and sesaminol diglucoside). The HPLC system was equipped with a reversed-phase column, Develosil ODS-UG-5, 4.6 × 150 mm (Nomura Chemical Co., Japan) and an ultraviolet-visible detector at 290 nm. The mobile phase was a linear gradient from solvent A, methanol: water (30 : 70, v/v), to solvent B, methanol: water (80 : 20, v/v), in 40 min and flow rate was set at 1.0 mL/min. Running time was 60 min for each sample. Each peak of lignan compounds was identified for further analysis with LC-MS (HCTultra, Bruker Daltonics Inc., USA) and HPLC retention time and UV spectra were compared with each lignan standard (Ryu *et al.*, 1998; Moazzami *et al.*, 2006).

For fatty acid analysis, 1 mL of hexane extract was transferred into the reaction bottle and concentrated under nitrogen flow at 70 °C. For saponification of the extract (oil), 0.5 mL of 0.5N NaOH (sodium hydroxide) solution was added to react at 100 °C for 10 min and allowed to cool. And then 0.5 mL of 14% BF_3 (boron trifluoride) solution was added and reacted at 100 °C for 10 min for the esterification of fatty acid compounds. After cooling, 1.5 mL of hexane and 1.0 mL of distilled water were mixed, partitioned in hexane, and the upper layer (containing fatty acid methyl esters in hexane extract) was transferred into 2 mL sample bottle before GC injection for fatty acid analysis. The GLC system (6890N GC, Agilent Technologies Co., USA) equipped with a flame ionization detector (FID) and a HP-Innowax capillary column (30 m length × 0.25 mm i.d., film 0.25 μm, J&W Scientific, Agilent Technologies Co., USA) was used. The oven temperature was raised from 160 °C (holding for 1 min.) to 230 °C at a constant rate of 5 °C/min., and then held for 10 min. The injector and detector port temperature were kept at 230 and 250 °C, respectively. The carrier gas was nitrogen at a flow rate of 1.0 mL/min and the split ratio at the injector port was 20 : 1. The analysis time was within 20 min.

Table 1. Effect of drought stress on seed yield and seed weight of sesame cultivars.

Cultivars[a]	Seed yield (g/plant)			Seed weight (mg/seed)	
	CTL	TRT	T/C	CTL	TRT
AS	7.87 ± 1.29	3.08 ± 1.94*	39	3.08 ± 0.15	2.73 ± 0.14
DB	11.69 ± 6.34	9.33 ± 3.72	80	2.74 ± 0.06	2.87 ± 0.06
HB	7.45 ± 1.21	3.85 ± 3.59	52	3.29 ± 0.04	3.16 ± 0.16
HS	6.89 ± 3.07	2.41 ± 1.56	35	2.87 ± 0.25	2.89 ± 0.15
HSN	5.69 ± 2.29	5.16 ± 0.45	91	3.04 ± 0.06	3.00 ± 0.15
JB	4.74 ± 2.13	4.18 ± 1.85	88	2.74 ± 0.21	3.02 ± 0.28
NB	12.07 ± 1.83	9.57 ± 4.06	79	3.06 ± 0.19	3.03 ± 0.05
ND	10.12 ± 4.44	5.89 ± 1.16	58	2.93 ± 0.27	2.78 ± 0.11
NS	9.80 ± 1.56	6.15 ± 0.59*	63	2.77 ± 0.06	2.94 ± 0.12
PA	5.23 ± 3.61	2.66 ± 0.71	51	3.12 ± 0.04	2.94 ± 0.21
PN	6.84 ± 1.13	4.14 ± 2.00	61	3.13 ± 0.12	3.01 ± 0.03
PS	6.70 ± 0.92	3.91 ± 0.15**	58	2.92 ± 0.23	3.00 ± 0.08
SB	5.88 ± 3.17	3.49 ± 1.25	59	3.08 ± 0.12	2.83 ± 0.04
SBN	5.87 ± 1.87	5.81 ± 1.73	99	3.05 ± 0.03	2.92 ± 0.07
SD	9.36 ± 1.62	5.22 ± 1.28*	56	2.97 ± 0.11	2.90 ± 0.04
SW	9.54 ± 1.94	6.95 ± 2.06	73	3.02 ± 0.18	2.95 ± 0.20
TB	9.20 ± 4.62	5.18 ± 2.05	56	3.01 ± 0.06	2.95 ± 0.25
YB	3.84 ± 1.10	4.06 ± 1.41	106	2.92 ± 0.25	2.88 ± 0.15
Mean	7.68 ± 2.45	5.10 ± 1.75		2.99 ± 0.14	2.93 ± 0.13
T/C	100	66		100	98

[a] Cultivars listed were 18 Korean recommended varieties explained in text; CTL, control, well watered; TRT, treatment, water-deficit stressed; T/C, The ratio of TRT to CTL; Values are means ± standard deviation (n=3); $^{*}p < 0.05$; $^{**}p < 0.01$.

Statistical analysis

Each treatment consisted of three replicates. All statistical analyses were conducted using the SAS System (SAS Institute Inc., USA) program. Analysis of variance (ANOVA), Duncan's multiple range (Duncan) tests and t-test were done to test differences ($p < 0.05$) between control and drought stress plots. Correlation among levels of each chemical composition for the differences between control and treatment plots was analyzed.

RESULTS AND DISCUSSION

Seed yield and weight

Seed yield and seed weight could be used as whole plant indicators of drought stress integrated over development. Depending on the indicator, the cultivars responded differently to drought treatment (Table 1). Drought during maturity stage reduced seed yield (34% of mean), as compared to well-watered condition. Varietal differences of seed yield reduction were relatively great, and significant reduction was observed in such cultivars as AS, NS, PS and SD. However, there were no significant differences between drought-stressed and well-watered plots for seed weight (Table 3). The trait of seed weight was not affected by drought stress and was not correlated with seed yield (data not shown). Of 18 cultivars evaluated in this study, the cultivars of HSN, SBN, and YB were resistant to drought when their seed yields reduced less than 10% for drought stress (Table 1).

Lignans

Changes of lipid-soluble lignans, sesamin and sesamolin, and water-soluble lignan glycosides, sesaminol triglucoside and sesaminol diglucoside in response to drought stress were shown in Table 2. The total lignans and lignan glycosides showed significant differences in different cultivars (C) and drought treatment (T) (Table 3). The C × T interactions for sesamin, total lignans and sesaminol triglucoside were also significantly different. It means that the effect of drought treatment on the chemical composition of sesame seeds can be changed in different cultivars. However, there were no significant C × T interactions for sesamolin, sesa-

Table 2. Effect of drought stress on lignans and lignan glycosides contents in seeds of sesame cultivars.

Cultivars[a]	Lipid-soluble lignans (mg/g)				Water-soluble lignan glycosides (mg/g)			
	Sesamin		Sesamolin		STG		SDG	
	CTL	TRT	CTL	TRT	CTL	TRT	CTL	TRT
AS	3.16	2.01*	2.66	2.52	0.57	0.88	0.04	0.07
DB	0.84	1.50	1.50	1.95	1.37	0.99	0.08	0.05
HB	2.84	2.11	2.81	2.63	0.32	0.61	0.02	0.04
HS	2.49	1.18*	3.03	1.96**	0.80	0.97	0.06	0.08
HSN	1.94	1.64	2.26	2.49	0.73	0.78	0.06	0.06
JB	4.15	1.07*	3.57	1.66	0.34	0.96*	0.02	0.06*
NB	4.06	3.76	3.83	3.86	0.37	0.43	0.02	0.02
ND	0.93	2.97	1.87	3.33	1.05	0.68	0.06	0.04
NS	4.12	2.11*	3.21	2.33	0.22	0.79*	0.01	0.05
PA	0.31	0.97	1.08	1.42	1.35	1.07	0.10	0.09
PN	3.27	2.30	2.57	1.99	0.35	0.55*	0.02	0.03
PS	3.19	2.25	2.89	2.51	0.64	0.93	0.04	0.06
SB	3.14	2.06	2.74	2.16	0.44	0.64	0.03	0.05
SBN	3.12	3.23	3.02	3.24	0.64	0.59	0.04	0.04
SD	1.99	2.03	2.59	2.42	0.73	0.88	0.04	0.05
SW	0.91	1.22	1.46	1.66	0.91	1.07	0.08	0.09
TB	2.55	2.42	2.17	2.54	0.57	0.82	0.04	0.06
YB	2.61	2.78	3.30	3.18	0.49	0.56	0.03	0.03
Mean	2.54	2.09	2.59	2.43	0.66	0.79	0.044	0.055
T/C	100	82	100	94	100	119	100	125

[a]Cultivars listed were Korean recommended varieties explained in text; CTL, control, well watered; TRT, treatment, water-deficit stressed; T/C, The ratio of TRT to CTL; STG, sesaminol triglucoside; SDG, sesaminol diglucoside; Values are the mean of three replicates; *p < 0.05; **p < 0.01.

Table 3. Analysis of variance for seed yield and lignan contents as influenced by drought stress.

Source of variance	Df	Mean squares							
		Seed yield	Seed weight	Sesamin	Sesamolin	TL	STG	SDG	TLG
Cultivars (C)	17	21.8**	0.05*	3.42**	1.89**	9.77**	0.28**	0.0022**	0.33**
Drought treatment (T)	1	142.7**	0.04	4.41*	0.43	8.41*	0.39**	0.0028*	0.46**
C × T	17	5.2	0.03	1.69*	0.69	4.41*	0.09*	0.0004	0.10
Error	62	5.7	0.01	0.75	0.39	2.08	0.05	0.0004	0.06

Df, degree of freedom; TL, total lignan, the sum of sesamin and sesamolin contents; STG, sesaminol triglucoside; SDG, sesaminol diglucoside; TLG, total lignan glycosides, the sum of STG and SDG contents; *p < 0.05; **p < 0.01.

minol diglucoside and total lignan glycosides. On average, sesamin content decreased by 82% ($P < 0.05$), while two lignan glycosides increased by 119% and 125% as compared to control, respectively although the responses of individual cultivars were different ($P < 0.01$, Table 3). The large increases in level of sesaminol triglucoside due to drought treatment were observed in cultivars, JB, NS and PN. On the other hand, significant decreases in sesamin content were observed in AS, HS, JB and NS. Changing patterns of increase or decrease in sesamolin and sesaminol diglucoside were different for HS and JB, respectively (Table 2). The results indicates that the level of lignan compounds in sesame seed generally was influenced by drought stress but the responses to drought were very different depending on sesame cultivars. To understand their different responses to drought stress, biochemical mechanism for accumulation of lignan compounds and the cellular response process of seed under drought condition should be investigated, especially in different cultivars and stress conditions.

Table 4 displays the relationship between lignans and lignan glycosides, based on the ratios (T/C) of drought-stressed plots (T) to control plots (C) as altered by drought treatment. The coefficients of correlation were high above 0.872 among lignans and above 0.987 among lignan glycosides. Lignans and lignan glycosides were strongly or inversely associated. Total amount of chemical compound was not changed too much under stress condition, but the levels of individual lignan compounds were changed into an increase of sesaminol triglucoside and a decrease of sesamin. Therefore, chemical composition of sesame seed may be altered by environmen-

Table 4. Coefficients of correlation among the ratios to control changed by drought treatment in contents of lignans and lignan glycosides of sesame seeds.

Constituents	Sesamin	Sesamolin	TL	STG	SDG
Sesamolin	0.872**				
TL	0.961**	0.967**			
STG	-0.581*	-0.670**	-0.658**		
SDG	-0.543*	-0.657**	-0.631**	0.987**	
TLG	-0.582*	-0.673**	-0.660**	0.999**	0.989**

TL, total lignan, the sum of sesamin and sesamolin contents; STG, sesaminol triglucoside; SDG, sesaminol diglucoside; TLG, total lignan glycosides, the sum of STG and SDG contents; $^{*}p < 0.05$; $^{**}p < 0.01$.

Table 5. Effect of drought stress on oil content and fatty acid composition in seeds of sesame cultivars.

Cultivars[a]	Oil (%)		Fatty acid composition (%)							
			Pal		Ste		Ole		Lin	
	CTL	TRT	CTL	TRT	CTL	TRT	CTL	TRT	CTL	TRT
AS	48.8	53.1	7.7	7.8	5.4	5.5	42.3	44.8	44.5	41.9
DB	44.5	45.5	7.1	7.8	5.5	5.7	45.0	45.4	42.4	41.0
HB	47.1	46.4	7.7	8.0	4.6	4.4	42.3	41.6	45.4	46.1
HS	46.6	44.0	7.8	9.1	4.8	5.4*	42.2	44.7**	45.2	40.9**
HSN	48.3	44.6	7.6	7.5	5.1	5.5	43.9	45.2	43.4	41.8
JB	46.7	46.6	7.2	7.4	5.3	5.6	43.8	45.3	43.6	41.7
NB	46.2	44.2	8.1	7.9	5.0	5.6	42.4	44.3	44.4	42.3
ND	45.6	40.4	8.1	7.4	5.0	5.5	41.9	46.0	45.0	41.1
NS	46.2	43.1	8.3	8.2	5.7	5.7	42.2	45.1	43.8	41.0
PA	43.1	46.3	7.7	7.7	5.3	5.6	44.3	45.0	42.7	41.7
PN	43.4	44.0	7.6	7.7	5.5	5.6	43.2	43.3	43.7	43.4
PS	49.0	47.1	7.3	7.6	5.1	5.4	42.8	44.7*	44.7	42.4*
SB	48.4	53.2	8.1	8.4	5.2	5.4*	41.0	40.3	45.7	45.9
SBN	51.8	47.9	7.9	8.0	4.9	5.4	42.0	44.6	45.2	42.0*
SD	48.6	47.2	7.4	7.5	5.5	5.7*	43.1	44.1*	44.0	42.6*
SW	46.7	45.5	8.4	8.3	4.7	5.2*	43.0	43.6	44.0	42.9
TB	48.7	48.1	8.2	8.1	5.0	5.3	41.5	42.5	45.3	44.1
YB	47.4	49.4	7.4	7.6	5.2	5.3	41.2	42.0	46.2	45.1
Mean	47.1	46.5	7.72	7.85	5.14	5.41	42.7	44.0	44.4	42.7
T/C	100	99	100	102	100	105	100	103	100	96

[a] Cultivars listed were Korean recommended varieties explained in text; CTR, control, well watered; TRT, treatment, water-deficit stressed; T/C, The ratio of TRT to CTL; Pal, palmitic acid; Ste, stearic acid; Ole, oleic acid; Lin, linoleic acid; $^{*}p < 0.05$; $^{**}p < 0.01$.

Table 6. Analysis of variance for oil content and fatty acid composition as influenced by drought stress.

Source of variance	Df	Mean squares				
		Oil	Pal	Ste	Ole	Lin
Cultivars (C)	17	26.5**	0.66**	0.40**	6.46**	7.38**
Drought treatment (T)	1	15.0	0.38	1.79**	46.46**	78.28**
C × T	17	9.8	0.23*	0.06	2.04	2.28
Error	62	11.2	0.13	0.04	1.35	1.37

Df, degree of freedom; Pal, palmitic acid; Ste, stearic acid; Ole, oleic acid; Lin, linoleic acid; * $p < 0.05$; ** $p < 0.01$.

Table 7. Coefficients of correlation among the ratios to control changed by drought treatment in oil content and fatty acid composition of sesame seeds.

Constituents	Oil	Pal	Ste	Ole
Pal	0.199			
Ste	-0.381	-0.164		
Ole	-0.548*	-0.297	0.475*	
Lin	0.541*	0.011	-0.574*	-0.936**

Pal, palmitic acid; Ste, stearic acid; Ole, oleic acid; Lin, linoleic acid; *$p < 0.05$; **$p < 0.01$.

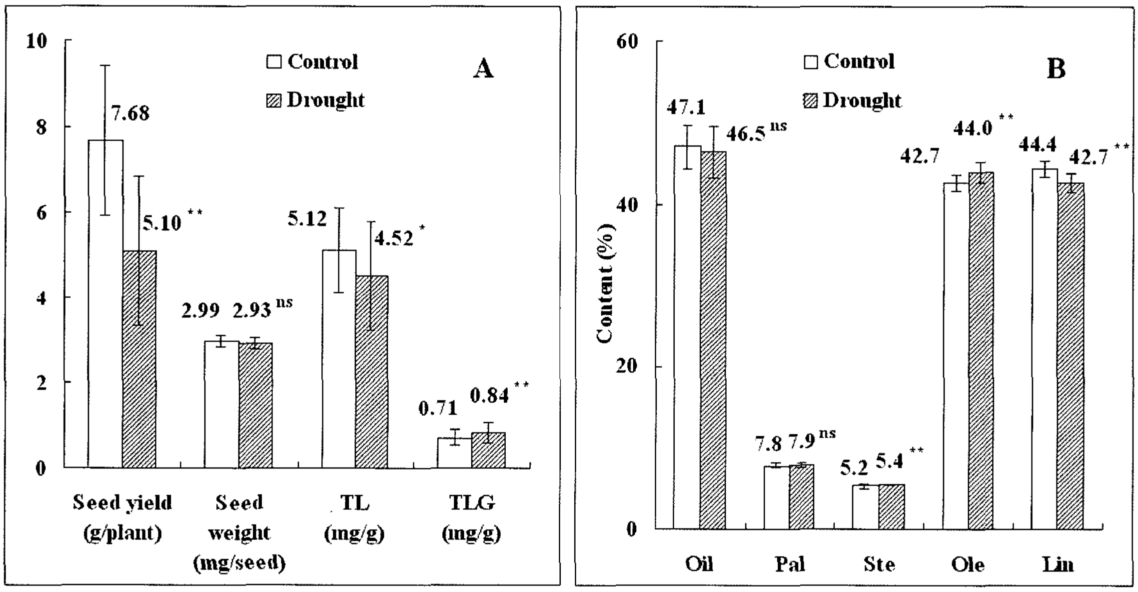

Fig. 1. Changes of seed yield and lignans contents (A), and oil content and fatty acid composition (B) of sesame seeds as influenced by drought stress. TL, total lignans content; TLG, total lignan glycosides; Pal, palmitic acid; Ste, stearic acid; Ole, oleic acid; Lin, linoleic acid; * $p < 0.05$; ** $p < 0.01$; ns, not significant.

tal stresses, and in particular, oxidative stability of seed oil may be increased because sesaminol glucosides have stronger antioxidative activity than sesamin and sesamolin.

Oil and fatty acid composition

Changes of oil content and individual fatty acid composition of cultivars treated with drought stress are shown in Table 5. The highly significant differences among cultivars were appeared in oil content and fatty acid composition although the responses of individual cultivars were different. The significant differences in drought treatment were observed in stearic, oleic and linoleic acids except for oil content and palmitic acid composition (Table 6). It means that the differences between cultivars are greater than effect of drought treatment in oil content and palmitic acid composition, and probably the drought effect on stearic, oleic and linoleic acids varied depending on cultivars. Oil contents of cultivars were not changed too much and were relatively stable in the drought treatment. The level of oleic acid composition increased, while that of linoleic acid decreased by drought stress significantly. However, moderate increase of oleic acid and decrease of linoleic acid were observed, respectively, in cultivars of HS, PS and SD. The significant decreases of linoleic acid composition were observed in HS, PS, SBN and SD out of the 18 cultivars, showing adverse effect to oleic acid composition (Table 5). But individual cultivars showed very different responses to drought treatment, and so it need further studies applying different treatment time and period as well as investigating change of chemical composition after treatment. The correlations between oil content and individual fatty acid compositions for the ratios of drought treatment to control plots are displayed in Table 7. Oleic and linoleic acid were strongly and negatively correlated (r = -0.936**) and oil content was associated with oleic (r = -0.548*) and linoleic acids (r = 0.541*). The increase of oleic acid by drought treatment accompanied the decrease of linoleic acid with adverse changes of oil content. These results showed that fatty acid composition of sesame seed was changed under drought condition though oil content slightly decreased.

Total lignan glycosides content and oleic acid composition were significantly increased in response to drought treatment while total lignans content and linoleic acid composition were decreased, with little effect on seed weight and oil content (Fig. 1), even though the responses of cultivars to drought stress were very different. Regardless of the potential benefits that the drought stress treatment imposed on sesame plant in terms of increased sesaminol triglucoside and sesaminol diglucoside concentration, the overall total chemical yields of most sesame cultivars were lower than that of well-watered control. This decrease in chemical yield predominantly resulted from the adverse effects of drought stress on the concentration of lignans and fatty acid composition. As a matter of fact, we only considered general trend of increase or decrease of chemical composition in sesame under drought condition. Further studies should be required to understand different responses of sesame cultivars under various stress conditions and periods.

In conclusion, these results demonstrate that depending on cultivating cultivars and environmental conditions, sesame seeds can contain very different amounts and proportion of bioactive compounds such as antioxidant compounds related to the quality of sesame seeds.

ACKNOWLEDGEMENTS

This study was supported by the Korea Research Foundation Grant (R05-2003-000-11071-0) funded by Korean Government (MOEHRD).

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