CHARACTERIZATION OF CHILLING SENSITIVITY OF TROPICAL AND TEMPERATE GRASSES

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ABSTRACT

C16-C18 fatty acid composition of some lipids in several species of temperate and tropical grasses were measured. The fatty acid composition of phosphatidylglycerol (PG) and sulfoquinovosyl diglyceride (SQDG) indicated significant differences between temperate and tropical grasses. Especially the differences of the fatty acid composition of PG were remarkable. The unsaturated fatty acid content of PG in tropical grasses was lower than the contents in temperate grasses. These differences constantly appeared through the year. These differences were caused by the low content of polyunsaturated fatty acids, or the low contents of C18 fatty acids.

KEYWORDS

Chilling sensitivity, fatty acid composition, tropical and temperate grasses, phosphatidylglycerol, acyltransferase, desaturase

INTRODUCTION

Gramineae are widespread among very diverse climatic conditions. Grasses are usually classified into two types, temperate and tropical grasses. In Japan, almost all of the tropical grasses fall into dormancy or death because of frost or low temperatures in winter. Although tropical grasses show good resistance to the moist and high temperature summers, the utilization of tropical grasses is restricted by winter death and dormancy. On the other hand, temperate grasses have good resistance to low temperature or chilling conditions but are sensitive to disease and drought conditions.

In the past decade, it has been revealed that chilling sensitivity is controlled by the fatty acid unsaturation of PG (Murata et al., 1992). Although, inter families chilling sensitivity has been explained, it is still unknown if the inter genera chilling sensitivity is controlled by the same mechanism.

Our objectives were to determine the fatty acid composition of several genera, and to ascertain whether differences in inter-genera fatty acid composition are similar to diffences in inter-family fatty acid composition.

MATERIAL AND METHODS

Tropical grasses —In the cases of vegetative propagate tropical grass species, some parts of established turf were transplanted into 1/5000 wagnel pots. Seed propagated species were seeded into 1/5000 wagnel pots. Growth occured under no temperature control and under irrigated conditions, 5 g leaf samples were collected on Aug. 30th, 1993.

Temperate grasses —Leaf samples of Timothy and Festuca-lolium were collected from an already established turf. Leaf samples of other species were collected under the same conditions as the seed propagated tropical grasses. All samples were stored at -120 ^{o}C until use.

All lipids were extracted and stored at -20 ^{o}C until use. Lipid classification was performed by 2-dimensional Thin Layer Chromatography. Each spot was extracted and methylated. Fatty acid composition of each lipid was analyzed by Gas Chromatography (Shimazu 14A) equipped with high polarity capillary column .

RESULTS

Unsaturated Fatty Acid Contents of Lipids of Leaves. Table 1 shows the unsaturated fatty acid content of some lipids of temperate and tropical grasses. The unsaturated fatty acid contents of PG, SQDG, MGDG and DGDG in temperate grasses were significantly higher than tropical grasses.The significant differences of unsaturated fatty acid contents of PG and SQDG were remarkable among these two grasses. The unsaturated fatty acid content of PG in tropical grasses was 36.2%-41.3%, and temperate grasses was 40.9%-55.4%. The unsaturated fatty acid content of some cultivars were quite similar to each other (data not shown). The order of the unsaturated fatty acid content of PG seemed to indicate chilling sensitivity for these grasses. The interaction between unsaturated fatty acid content of PG and chilling sensitivity could not be manifested in SQDG. The zoysiagrass (Zoysia japonica Steud.)entries all showed high contents of unsaturated fatty acids of PG among the tropical grasses. An ecotype of zoysiagrass which was collected in the most northern part of original habitat showed the highest content of unsaturated fatty acid of PG.

Fatty Acid Compositions of PG. Table 2 shows the fatty acid composition of PG. PG of temperate grasses contained high amounts of C18 unsaturated fatty acid, and contained low amounts of C16 fatty acid. And 16:1t fatty acid was dominant in the C16 fatty acids in temperate grasses. 18:3 fatty acid was the major component in temperate grasses. On the other hand, PG of tropical grasses contained a relatively low amount of C18 unsaturated fatty acid, and contained a high amount of C16 fatty acids. 16:0 was dominant in tropical grasses . It is well known that the contribution of C16 and C18 fatty acid of lipids is influenced by the affinity of glycerol 3-phosphate acyltransferase (Cronan and Roughan, 1987). The distribution of C16 and C18 seemed to be caused by this acyltransferase. The fatty acid composition of tropical grasses showed variability mostly in C18 fatty acid. In zoysiagrass and bahiagrass (*Paspalum notatum Flugge*.), it appeared that the 18:3 fatty acid content was considerably lower than temperate grasses, but Rhodesgrass and bermuda grass have a similar amount of 18:3 fatty acid as temperate grasses. And the other tropical grasses had an intermediate level of 18:3. These distributions for fatty acid content showed no significant change among the other several samplings (data not shown).

DISCUSSION

The fatty acid composition of temperate grasses was similar to winter plants such as Arabidopsis, and tropical grasses were similar to summer plants such as Tabacco as described in Murata et al., (1982). It is clearly revealed by Murata et al., (1992) that these differences were caused by glycerol 3-phoshpate acyltransferase, and chilling sensitivity could engineer transformation of this gene. Thus, we consider that the difference in the fatty acid composition between temperate and tropical grasses is also attributable to different affinities of glycerol 3-phosphate acyltransferase.

Temperate grasses have high contents of both C18 fatty acid and polyunsaturated fatty acid of linolenic acid. On the other hand, tropical grasses have only one of them. Zoysia grass only has a high content of C18 fatty acid, but low content of polyunsaturated fatty acid of linolenic acid. The further analysis of 32 individual ecotypes of zoysia grasses revealed that this low content of polyunsaturated fatty acid was consistent in this species (data not shown). It is well known that the distribution of linolenic acid and linolenic acid is influenced by fatty acid desaturase in several plants (Slabas and Fawcett, 1992). Therefore it seems that the zoysia grass has less activity of fatty acid desaturase.

REFERENCES

Murata, N., N. Sato, N. Takahashi and Y. Hamazaki. 1982. Compositions and positional distributions of fatty acid in phospholipids from leaves of chilling-sensitive and chilling-resistant plants. Plant and Cell Physiol. **23**: 1071-1079.

Cronan, J.E.J. and P.G. Roughan. 1987 Fatty acid specificity and selectivity of the chloroplast sn-glycerol 3-phoshpate acyltransferase of the chilling sensitive plant, Amaranthus lividus. Plant Physiol. **83**: 676-680.

Murata, N., O. Ishizaki-Nishizawa, S. Higashi, H. Hayashi, Y. Tasaka, and I. Nishida. 1992. Genetically engineered alteration in the chilling sensitivity of plants. Nature **35**6: 710-713.

Slabas, A.R. and T. Fawcett. 1992 The biochemistry and molecular biology of plant lipid biosynthesis. Plant Molecular Biology **19**: 169-191.

Table 1

Unsaturated fatty acid contents of Lipids (%)*z of several tropical and temperate grass species.

	Lipids					
Species	**PG**	**SQDG**	**PC**	**PE**	**MGDG**	**DGDG*v**
Tropical grasses						
Bahiagrass	36.2	55.1	65.9	67.5	98.3	83.5
Rhodesgrass	38.6	61.2	70.7	76.1	97.6	81.0
Bermudagrass	38.8	59.0	71.3	70.9	97.7	82.1
Dallisgrass	41.7	68.4	68.4	62.6	97.4	84.7
Zoysiagrass *y	43.4	53.6	74.4	78.0	97.5	79.6
Weeping lovegrass	44.7	58.8	72.6	72.4	98.4	84.4
Zoysiagrass *x	44.7	51.6	71.4	75.5	96.9	81.0
Zoysiagrass *w	47.6	62.7	75.5	77.6	98.3	85.1
Temperate grasses						
Tall fescue	42.4	54.5	66.7	58.5	97.6	81.0
Reed canarygrass	44.1	57.6	68.2	64.3	98.2	80.4
Bentgrass	44.6	64.9	70.6	62.5	98.5	86.1
Perennial ryegrass	48.8	66.4	72.3	65.9	99.1	89.5
Kentucky bluegrass	48.9	65.5	70.5	63.5	97.6	79.9
Meadow fescue	54.4	71.3	76.0	73.9	99.1	88.4
Festuca-lolium	55.2	70.1	72.8	72.8	99.0	89.2
Timothy	55.4	74.5	80.1	78.3	98.9	88.9

*v PG;phosphatydilglycerol. SQDG;sulfo-quinovosyl-diacylglycerol. PC;phosphatidylcholine. PE;phosphatidylethanolamine. MGDG;monogalactosyl-diacylglycerol DGDG ; digalactosyl-diacylglycerol

*w Zoysia japonica, an ecotype from most northern part of Japan

*x Zoysia matrella, an ecotype from the southern part of Japan

*y Zoysia tenuifolia, an ecotype from southern part of Japan

*z the contents of 16:1c, 18:1c,18:2c and 18:3c fatty acids in C16 and C18 fatty acids.

Table 2

Fatty Acid Compositions of PG(%)*z

Species	16:0	16:1c	16:1t	18:0	18:1	18:2	18:3 *v
Tropical zone grasses							
Bahiagrass	31.6	0.6	30.5	1.7	2.2	20.9	12.6
Rhodesgrass	32.0	0.6	27.6	1.8	2.4	4.3	31.3
Bermudagrass	26.3	0.5	32.2	2.4	2.7	8.4	27.4
Dallisgrass	41.5	0.0	14.6	2.2	3.1	17.9	20.1
Zoysiagrass *y	42.6	0.4	12.2	1.8	13.0	21.5	8.6
Weeping lovegrass	46.8	1.0	6.2	2.3	9.5	12.4	21.8
Zoysiagrass *x	41.5	0.1	12.4	1.4	14.6	21.3	8.6
Zoysiagrass *w	38.6	0.1	12.2	1.7	11.4	26.2	10.0
Temperate zone grasses							
Tall fescue	25.2	0.1	31.3	1.2	3.7	12.0	26.6
Reed canarygrass	17.8	0.3	36.9	1.2	2.9	13.2	27.7
Bentgras	18.5	0.0	35.7	1.2	2.4	5.4	36.7
Perennial ryegrass	26.7	0.7	26.4	1.0	4.1	6.8	37.3
Kentucky bluegrass	21.8	0.0	28.3	1.0	4.5	7.6	36.7
Meadow fescue	15.9	0.0	29.2	0.5	4.3	9.6	40.5
Festuca-lolium	20.1	0.0	23.9	0.6	3.4	12.9	39.1
Timothy	20.1	0.0	23.9	0.6	3.4	12.9	39.1

*v 16:0 ; palmitic acid. 16:1c ; palmitoleic acid. 18:0 ; stearic acid. 18:1 ; oleic acid 18:2 ; linoleic acid. 18:3 ; linolenic acid

*w,*x,*y also shown in Table 1

*z Percent distribution among C16 and C18 fatty acids