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ALTERATIONS IN GLYCOLIPIDS OF WHEAT AND BARLEY LEAVES UNDER WATER STRESS

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Key Word Index—*Triticum aestivum*; wheat; *Hordeum vulgare*; barley; Gramineae; glycolipids; tillering; ear emergence; grain filling; water stress.

Abstract—Glycolipids of leaves from water-stressed and stress-recovered wheat and barley plants were studied. A decrease in the content of total glycolipid, monogalactosyl diacylglycerol (MGDG) and digalactosyl diacylglycerol (DGDG) was observed under water stress in both crops. The decrease in glycolipids was greatest in varieties requiring more water than in those requiring less water. The latter regained their glycolipids better on recovery from stress.

INTRODUCTION

Water deficits in plants, brought about by drought, influence many important physiological and biochemical processes which ultimately affect yield [1]. Increase in water stress results in a slower accumulation of chlorophyll [2, 3], increased mesophyll resistance [4], increased stomatal diffusion resistance [5, 6], decreased activity of photosynthetic enzymes [7] and diminished photochemical and biochemical activities of chloroplasts [8]. Besides these the decreased photosynthetic activity may also be due to the alterations in glycolipids of leaves which form a major constituent of chloroplast lamellae [9]. Results reported here are concerned with changes in the glycolipids of leaves associated with water stress. Varieties of wheat (C-306) and barley (C-138) requiring less water and others S-308 (wheat) and BG-25 (barley) requiring more water were investigated.

RESULTS

Total glycolipids content of leaves increased with age in both wheat (Table 1) and barley (Table 2) varieties. The largest amount of glycolipid was observed at the grain-filling stage; this was seen more markedly in barley, BG-25. The major glycolipids observed by TLC were MGDG and DGDG; both increased in wheat (Table 1) and barley (Table 2) up to the grain-filling stage. Water stress resulted in a decrease in MGDG and DGDG content at all stages in both crops, in contrast to the increase noted in phospholipids [10]. The decrease was greater in the varieties requiring more water: wheat S-308 and barley BG-25. The largest decrease was 53% in MGDG and 58% in DGDG at the tillering stage in S-308 wheat leaves. Leaves of varieties requiring more water which were stressed at tillering and ear emergence showed poor recovery on subsequent irrigation, while leaves of varieties requiring less water showed nearly 90% recovery in glycolipid contents (Table 3).

DISCUSSION

Glycolipids are among the major lipids of leaves [11] and their content increases with maturity [12] and greening [13]. Reduction in glycolipid has been reported to occur under a variety of conditions such as water stress induced by polyethylene glycol [14], temperature stress [15], senescence [16] and salinity [17]. Glycolipids are important components of chloroplasts and may be involved in carbohydrate transport [18, 19] fatty acid synthesis [20], and photoreduction of cytochrome [21]. The decrease in total glycolipid, MGDG and DGDG could be due either to decreased synthesis or accelerated breakdown through increased galactolipase activity. Under *in vitro* conditions, hydrolysis of MGDG and DGDG is known to take place in solutions of high osmotic strength like sucrose and mannitol [9]. Galactolipid-hydrolysing enzymes lead to the formation of free fatty acids, MGDG and DGDG, which strongly inhibit the photoactivity of chloroplasts [22]. The observed decrease in glycolipids under water stress would lead to diminished photosynthetic rate. The adverse effect of stress was greater on the glycolipid content of varieties of both crops requiring more water. On rewatering of stressed plants there was an increase in the glycolipid content in both crops, though it remained lower than that in the unstressed plants. The near complete recovery in the glycolipid content in wheat C-306 and barley C-138 leaves indicates that glycolipid changes are reversible in varieties requiring less water. Reversible and irreversible changes related to water stress have been reported in glycolipids [23] and in the ultrastructural organization of chloroplasts of drought-resistant and water-loving varieties [24].

EXPERIMENTAL

Wheat varieties S-308 and C-306 and barley varieties BG-25 and C-138 were obtained from the Plant Breeding Department of this university. Water stress creation, lipid extraction, purification and fractionation was achieved as described in ref. [10]. Individual spots from TLC plates were scraped into test tubes and analysed for galactose content by the anthrone reagent [25].

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Table 1. Glycolipids of wheat leaves under water stress (mg/g dry wt)

	Tillering C	Tillering S	Ear emergence C	Ear emergence S	Grain filling C	Grain filling S
Cv. S-308						
Total glycolipids	7.08 ± 0.12	4.19 ± 0.07	10.27 ± 0.06	5.80 ± 0.01	10.46 ± 0.06	6.80 ± 0.01
MGDG	2.68 ± 0.08	1.26 ± 0.65	4.46 ± 0.17	2.20 ± 0.04	5.96 ± 0.06	3.09 ± 0.01
DGDG	2.19 ± 0.08	0.92 ± 0.05	3.51 ± 0.11	1.64 ± 0.05	4.05 ± 0.11	2.10 ± 0.02
Cv. C-306						
Total glycolipids	6.00 ± 0.09	4.50 ± 0.08	7.77 ± 0.10	5.68 ± 0.10	8.88 ± 0.09	8.03 ± 0.09
MGDG	2.26 ± 0.09	1.44 ± 0.04	3.57 ± 0.07	2.40 ± 0.08	5.15 ± 0.05	4.32 ± 0.07
DGDG	1.92 ± 0.09	1.12 ± 0.05	2.84 ± 0.08	1.82 ± 0.12	3.55 ± 0.09	3.05 ± 0.03

C, control and S, stress.
All observations are mean of three replicates ±s.d.

Table 2. Glycolipids of barley leaves under water stress (mg/g dry wt)

	Tillering C	Tillering S	Ear emergence C	Ear emergence S	Grain filling C	Grain filling S
Cv. BG-25						
Total glycolipids	6.67 ± 0.08	3.87 ± 0.06	9.60 ± 0.11	5.17 ± 0.07	12.18 ± 0.08	8.03 ± 0.10
MGDG	2.60 ± 0.07	1.23 ± 0.03	4.20 ± 0.04	1.99 ± 0.05	7.31 ± 0.01	4.42 ± 0.07
DGDG	2.86 ± 0.07	1.32 ± 0.05	3.80 ± 0.10	1.83 ± 0.05	4.57 ± 0.05	2.77 ± 0.11
Cv. C-138						
Total glycolipids	6.64 ± 0.09	5.32 ± 0.06	9.86 ± 0.04	7.44 ± 0.09	10.01 ± 0.01	9.19 ± 0.05
MGDG	2.42 ± 0.10	1.64 ± 0.02	4.34 ± 0.10	3.11 ± 0.08	5.77 ± 0.09	5.20 ± 0.08
DGDG	2.73 ± 0.07	1.75 ± 0.06	2.73 ± 0.07	1.75 ± 0.05	3.95 ± 0.08	3.58 ± 0.12

C, control and S, stress.
All observations are mean of three replicates ±s.d.

Table 3. Glycolipids of wheat and barley leaves upon release of water stress (mg/g dry wt)

	Wheat				Barley			
	Cv. S-308		Cv. C-306		Cv. BG-25		Cv. C-138	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Total glycolipids	6.53 ± 0.11	6.44 ± 0.06	7.81 ± 0.09	7.79 ± 0.09	7.55 ± 0.12	7.49 ± 0.10	9.00 ± 0.05	9.20 ± 0.10
MGDG	2.86 ± 0.11	2.98 ± 0.06	4.09 ± 0.03	4.18 ± 0.06	3.65 ± 0.10	3.74 ± 0.06	4.88 ± 0.10	5.08 ± 0.04
DGDG	1.81 ± 0.11	2.01 ± 0.04	2.93 ± 0.06	2.94 ± 0.10	2.28 ± 0.06	2.45 ± 0.04	3.43 ± 0.07	3.45 ± 0.01

S_1 and S_2: release of stress created at tillering and ear emergence, respectively.
All observations are mean of three replicates ±s.d.

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REFERENCES

1. Begg, J. E. and Turner, N. C. (1976) *Adv. Agron.* **28**, 161.
2. Virgin, H. I. (1965) *Physiol. Plant.* **18**, 994.
3. Bourque, O. P. and Naylor, A. W. (1971) *Plant Physiol.* **47**, 591.
4. Toole, J. C. O., Crookston, R. K., Treharne, K. J. and Ozbun, J. L. (1976) *Plant Physiol.* **57**, 465.
5. Barrs, H. D. (1968) *Physiol. Plant.* **21**, 918.
6. Boyer, J. S. (1970) *Plant Physiol.* **46**, 233.
7. Huffaker, R. C., Radin, T., Kleinkopf, G. E. and Cox, E. L. (1970) *Crop. Sci.* **10**, 471.
8. Boyer, J. S. and Bowen, B. L. (1970) *Plant Physiol.* **45**, 612.
9. Wintermans, J. F. G. M., Helmsing, P. J., Permans, B. J. J., Gisbergen, J. V. and Collard, J. (1969) *Biochim. Biophys. Acta* **189**, 95.
10. Chetal, S., Wagle, D. S. and Nainawatee, H. S. (1980) *Phytochemistry* **19**, 1393.
11. Roughan, P. G. and Batt, R. D. (1968) *Analyt. Biochem.* **22**, 74.
12. Gray, I. K., Rumsky, M. G. and Hawk, J. C. (1967) *Phytochemistry* **6**, 107.
13. Roughan, P. G. and Boardman, N. K. (1972) *Plant Physiol.* **50**, 31.
14. Lechevallier, D. (1970) *Physiol. Veg.* **15**, 387.
15. Kleinschmidt, M. G. and McMohan, V. A. (1970) *Plant Physiol.* **46**, 290.

16. Draper, S. R. (1969) *Phytochemistry* **8**, 1641.
17. Izawa, S. and Good, H. E. (1966) *Plant Physiol.* **41**, 533.
18. Ferrari, R. A. and Benson, A. A. (1961) *Arch. Biochem. Biophys.* **13**, 185.
19. Benson, A. A. (1964) *Annu. Rev. Plant Physiol.* **15**, 1.
20. Gunsellden, G. and Selstam, E. (1976) *Physiol. Plant.* **37**, 35.
21. Chang, S. B. and Ludin, K. (1965) *Biochem. Biophys. Res. Commun.* **21**, 424.
22. Hirayama, O. and Nushida, T. (1978) *Agric. Biol. Chem.* **42**, 141.
23. Chetal, S., Wagle, D. S. and Nainawatee, H. S. (1981) *Plant Sci. Letters* **20**, 225.
24. Alieva, S. A., Tageeva, S. V., Tairbekw, M. G., Kasatkina, V. S. and Vagabwa, M. E. (1971) *Sov. Plant Physiol.* **18**, 416.
25. Trevelyan, W. F. and Harrisen, I. S. (1952) *Biochem. J.* **50**, 298.