gall inducing larvae were isolated by splitting the galls. Normal leaf portions almost of the same age and larvae free galls (hereafter referred to as galls) were used for study.

Total protein concentrations in the normal leaves and galls were estimated[3] after precipitation with 10% trichloro acetic acid. The extracts of both normal leaves and galls were made in 80% ethyl alcohol and acetone with 0·5 ml isopropyl alcohol as preservative. The free amino acids were separated by descending two-dimentional paper chromatography[4]. The total carbohydrates in 100 mg of dried leaf powder was estimated by calorimetric method[5]. The chlorophyll concentrations in the acetone (80%) extract was determined by direct measurements using spectronic '20[6].

There was a decrease in the concentration of total proteins in the galls compared to the normal leaves. The galls showed higher concentrations of leucine and iso-leucine when compared to normal leaf portions. Further, it had two additional amino acids, aspartic acid and hydroxy proline.

Estimation of total carbohydrates indicated a marked reduction in the galls. While the normal leaf portions had a carbohydrate concentration of 1·30 mg/g weight of leaf tissue, the infected portion had only 0·52 mg of carbohydrates/g weight of leaf tissue. The concentrations of chlorophylls *a* and *b* also decreased due to galling (chlorophyll *a* from 0·78 to 0·35: chlorophyll *b* from 0·93 to 0·50).

Decline in the protein content while increase in the amino acid concentration and accumulation of new amino acids can probably be explained with Vidyasekaran's[7] hypothesis, that proteolysis occurs during pathogenesis or as Goodman *et al.*[8] have proposed it could be due to the blockage of protein synthesis. While the galls exhibited increase in the concentration of amino acids, there was a significant drop in the total carbohydrate content. It is probable that the synthesis of amino acids is related to the decrease in the concentration of carbohydrates, supported by the fact that close metabolic relationships exist between 'head' compounds of each family of amino acids and carbon dioxide fixation and tri-carboxylic acid cycle[9]. It is also possible that reduction in carbohydrate content could be due to impairment of photosynthetic activity.

The authors thank Prof. Crispin Devadas, Department of Botany, Madras Christian College, for encouragement and help.

April 24, 1981.

1. Ananthakrishnan, T. N. and Muraleedharan, N., *Curr. Sci.*, 1974, 43, 216.
2. Gadal, P., *Marcellia*, 1974, **38**, 57.
3. Lowry, O. H., Rosebrough, N. J., Farr, A. L. and Randall, R. J., *J. Biol. Chem.*, 1951, **193**, 265.
4. Plummer, D. J., *An Introduction to Practical Biochemistry* (II Edn.), Tata McGraw-Hill, New Delhi, 1979.
5. Somogyi, M., *J. Biol. Chem.*, 1952, **200**, 145.
6. Harborne, J. B., *Phytochemical Methods*, Chapman and Hall, London, 1973.
7. Vidyasekaran, P., *Ph.D. Thesis*, T.N. Agricultural University, 1972.
8. Goodman, R. N., Kiraly, Z. and Zaitlin, M., *The Biochemistry and Physiology of Infectious Plant Diseases*, D. Von Nostrand Co., Inc., Princeton, N.J., 1967.
9. Fowden, L., *A. Rev. Pl. Physiol.*, 1967, **18**, 85.

REVERSAL OF DIKEGULAC-SODIUM INDUCED CHLOROPHYLL DEGRADATION AND CHLOROPHYLLASE ACTIVITY IN *HELIANTHUS ANNUUS* BY UREA

S. S. Purohit and K. Chandra
Department of Botany
Government Post-Graduate College
Nagaur 341 001, India

Dikegulac-sodium (sodium-7,3 : 4, 6-di-0-isopropylidene-α-xylo-2-furanosonate) or ATRINAL(R) is a biologically active new growth regulator which exhibits diverse effects on plant growth and development[2–9]. Recently, Purohit and Chandra[9] have shown that dikegulac-sodium induces senescence in detached leaves of *Avena sativa*, and loss of chlorophyll presumably mediated by increased levels of chlorophyllase. This work was extended to understand the hormonal induced senescence and its reversal by nitrogenous compounds which promote chlorophyll synthesis[4,11].

The fruits of *Helianthus annuus* L. var. EC 68414 were sown in mud pots (10 × 15) containing soil mixed with farm yard manure under natural day (11–13 hr) and temperature (25°–32°). Twenty-day plants were sprayed with distilled water or test solutions (Dikegulac 100, 250, 500, 750 mg/l and dikegulac 750 mg/l with 100, 250, 500 mg/l urea) on alternate day at 7·00 a.m. Ten pots were treated with each solution. On 50th day, leaves from each treatment were separately collected and washed with distilled water. Chlorophyll content and chlorophyllase activity were estimated in triplicate[9].

Data (Fig. 1) reveal that all the concentrations of dikegulac-sodium inhibited chlorophyll content. This

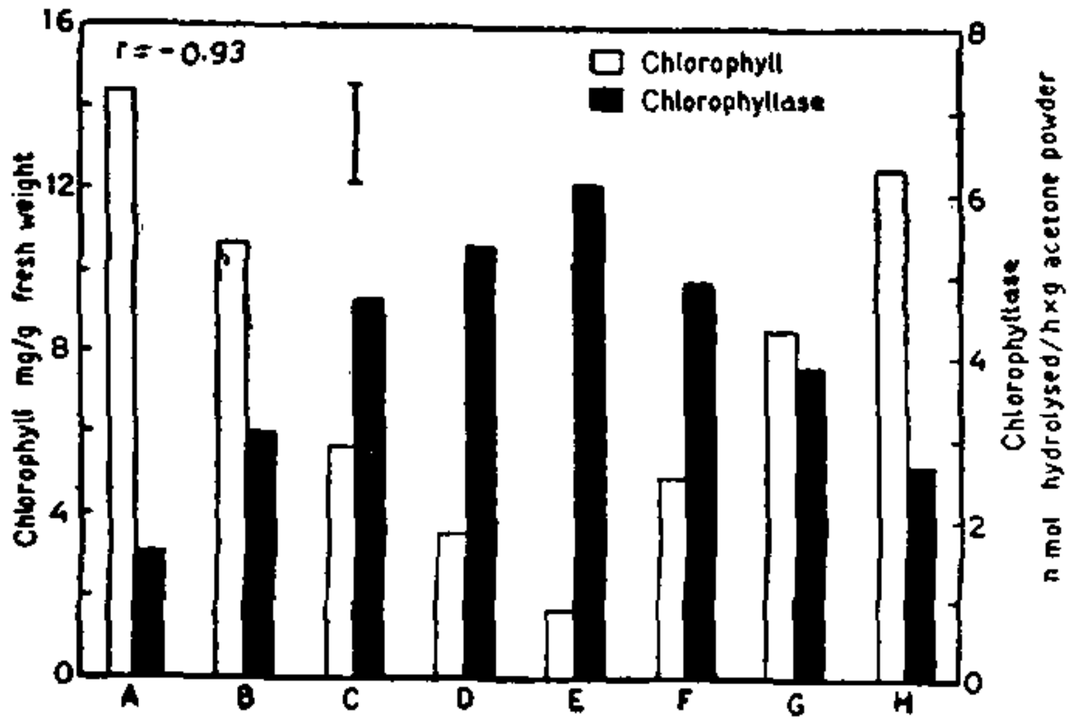

FIG. 1. Effect of dikegulac and urea used alone and in combination on chlorophyll retention and chlorophyllase activity in leaves on *Helianthus annuus*. The treatments are indicated as *A* = water; B = dikegulac 100 mg/l; C = dikegulac 250 mg/l; D = dikegulac 500 mg/l; E = dikegulac 750 mg/l; F = dikegulac 750 mg/l + urea 100 mg/l; G = dikegulac 750 mg/l + urea 250 mg/l; H = dikegulac 750 mg/l + urea 500 mg/l. Values are mean of three determinations. Vertical line indicates LSD ($p = 0{\cdot}05$).

loss of chlorophyll was high at higher concentrations of dikegulac. The loss of chlorophyll by dikegulac treatment was overcome by urea. The chlorophyllase activity was inversely proportional to chlorophyll retention (Karl Pearson's coefficient of correlation. $r = -0{\cdot}930$). Clearly chlorophyllase is involved in the protective effects of urea against chlorophyll loss.

Purohit and Chandra[9] observed that effect of dikegulac on chlorophyll degradation during senescence of detached leaves of *Avena sativa* is controlled by chlorophyllase. *It is also known* that the loss of chlorophyll may be mediated through increased ethylene level in dikegulac treated plants[2,10]. Since nitrogeneous compounds promote chlorophyll synthesis[4,11], urea antagonises the effect of dikegulac on chlorophyll loss. Therefore, it is possible that urea may directly reduce chlorophyllase activity or indirectly may reduce ethylene level which in turn decreases the enzyme activity.

The authors are grateful to Dr. R. Maag Ltd., Switzerland, Prof. B. Sabater (Spain) and to Prof. G. W. Barendse (The Netherlands) for help.

May 14, 1981.

1. Arzee, T. Langenauer, H. and Gressel, J., *Bot. Gaz.*, 1977, **138**, 18.
2. Bocion, P. F. and DeSilva, W. H., "Some effects of dikegulac on the physiology of whole plants and tissue : Interaction with plant hormones," In *Plant Growth Regulation*, ed. P. E. Pilet, Springer-Verlag, Berlin, 1977, p. 189.
3. Gressel, J., Kadouri, A., Atsmon, D. and Cohan, H., "Collections of abstracts of paper demonstrations," In *Plant Growth Regulation*, 9th International Conference on Plant Growth Substances, ed. P. E. Pilet, Springer-Verlag, 1977, p. 177.
4. Purohit, S. S., *Comp. Physiol. Ecol.*, 1979, **4**, 264.
5. —, *Ibid.*, 1980, **5**, 24.
6. —, *Ibid.*, 1980, **5**, 83.
7. —, *Ibid.*, 1980, **5**, 159.
8. — and Chandra, K., *Ibid.*, 1980, **5**, 246.
9. — and —, *Curr. Sci.*, 1980, **49**, 635.
10. Shimokawa, K., Shimada, S. and Yoco, K., *Sci. Hort.*, 1978, **8**, 129.
11. Vyas, L. N., Jain, S. L. and Sharma, S., *Biochem. Physiol. Pflanzen.*, 1975, **67**, 343.

RUMINATE ENDOSPERM IN *DILLENIA SUFFRUTICOSA* (GRIFF.) MARTELLI

J. DULCY ELIZABETH AND K. K. LAKSHMANAN
Botany Dept., Autonomous PG Centre
Madras University, Coimbatore 641 041

THE phenomenon rumination first reported in the nineteenth century[1,2] is now known in about 30 families of dicotyledons and one family in each of monocotyledons and gymnosperms[3]. Rumination due to unequal growth of the endosperm, rarely reported, as in *Elytraria*[4], *Nelsonia*[5] and *Haplanthus*[6] of Acanthaceae and also in *Psychotria*[7] belonging to Rubiaceae.

The devleopment of the ruminate endosperm in the seeds of *Dillenia suffruticosa* is reported here. Even at the young free nuclear stage, the protoplast of the endosperm at the chalazal half of the embryo sac becomes undulated (Figs. 1, 2). Cell wall formation sets in making the endosperm completely cellular (Fig. 3). At irregular loci the peripheral cells become dense, undergo mitotic divisions, forming group of cells of meristematic nature (Fig. 4). By further divisions and enlargement of cells the endosperm presents a well manifested ruminate condition. The ruminate endosperm pushes through the nucellar tissue and reaches the seed coat (Fig. 5).

In the majority of the genera, reported to have ruminate endosperm, it is the inner seed coat that causes rumination. In a few members of Rubiaceae and Acanthaceae, rumination is due to the activity