TECHNIQUES TO CHANGE THE NUMBER OF FLORET AND SEED ROWS IN THE SUNFLOWER CAPITULUM.

J. H. Palmer and L. F. Hernández.
Department of Botany, University of New South Wales, Sydney, 2033, Australia.

In the sunflower capitulum (head), disc florets and seeds are organised into distinct left and right turning spiral rows. The number of rows conform to the Fibonacci series, 21, 34, 55, 89, 144, with 55 and 89 being the most common in cultivated oilseed lines. The row number is not constant but decreases from the head rim to the centre, through 2 or 3 steps, with a common number linking the pairs together and forming the interlocking Fibonacci pattern that characterises the mature seed head (Fig.1). Environmental factors, for example, daylength and mineral nutrition can change disc floret row number although the Fibonacci pattern is always maintained (Palmer J. and Steer B.,1985. Field Crops Research, 11; 1-12). Three methods are described to remove the Fibonacci control of row number, without affecting disc floret initiation or seed production. Lines and hybrids used comprised Hysun 30, Sunfola 68-2, Suncross 150 and a Yugoslav Hybrid NS 44. The experiments were carried out on shoot apices of intact potted plants reared in a controlled environment cabinet under optimal growing conditions, during an 11 hr (SD) or 18 hr (LD) photoperiod.

(1). **Cytokinin Application.** Treatments commenced 18-25 days from sowing, when the shoot apex was 300-500 µm in diameter in the early dome stage of flower initiation, floral stage (FS) 3, prior to floret production (Marc J. and Palmer J.,1981. Field Crops Research, 4; 155-164). The cytokinin, benzyladenine (BA), was dissolved in 30% aqueous ethanol at a concentration of 0.5 mg ml^{-1}. This solution was applied directly to the terminal bud to give a daily dose of 50 µg, over a 5 day period. In 5 replicates, the control plants produced normal heads with 55/89 floret rows at the rim. 46% of BA treated plants showed no response; 54% produced heads showing varying degrees of irregularity in floret row organisation. 60% of these showed an increase in the number of disc floret rows to numbers which did not conform to the Fibonacci series (Fig. 2).The disc florets produced in the BA treatment appeared normal and gave fertile seeds.

(2). **Isolation of a Receptacle Segment.** The capitulum was used at FS 4 or 5, when the receptacle was a flat undeveloped disc, with a diameter ranging from 1.4-2.8 mm. A cylindrical wound was made in the receptacle surface with a sterile hypodermic needle to create a cylindrical plug of undifferentiated receptacle tissue 1 mm in diameter, which was isolated from lateral contact with the rest of the receptacle by a circular wound 50 µm wide and 200 µm deep, while retaining continuity with the subapical meristem. 96 plants were treated in in 4 replicates. Similar results were obtained in SD and LD. In LD, 3-6 days after creation of the plug, regularly spaced initials appeared around the plug rim. These rapidly formed involucral bracts and were followed by others which developed into either ray or disc florets (Fig.3). Similar floral organ initiation occurred around the outer rim of the wound. On the plug surface the disc florets were arranged in short spiral rows which extended to occupy the whole of the plug surface in about 9-12 days. The involucral bracts, ray and disc florets induced on the plug surface appeared to be normal in all respects. The base of the plug developed into a green stem-like structure and by the time of anthesis the plug resembled a miniature capitulum (Fig. 4), except that the disc florets were not organised into long spiral rows and the number of rows did not conform to the Fibonacci series. The disc florets produced fertile seeds.

(3). **Removal of Involucral Bracts in FS3.** Hysun 30 plants reared in LD were used. At FS 3, the first row of involucral bract primordia situated on the flank of the apical meristem, comprising about 30% of the final number, were removed. 30 plants were treated in this way in two replicates. This treatment caused a significant increase in capitulum diameter and in 55% of cases the capitula produced a new disc floret row pattern resulting from a number sequence called the "Lucas" sequence. This being the numbers generated by the fraction 47/76 and produced if the new disc floret primordia are theoretically arising with a divergence angle of approximately 99.5° (Jean R., 1986. Math. Biosci., 79; 127-154).

These techniques show that involucral bract and floret initiation, are developmental processes which can be separated from the system controlling the organisation of disc florets into rows. This finding excludes the theories of phyllotaxis as a basis for understanding floret production by the sunflower capitulum. Since the first two techniques are known to stimulate cell division activity, it seems possible that they induced the generation of additional floral organs by promoting a specific type of cell division (periclinal). The induced involucral bracts, ray and disc florets were invariably normal in appearance and function. This may be because the techniques employed served only to generate new floral initials which when formed automatically become self regulating structures that are able to produce functional floral organs. This view elevates the status of the floral organ initial to the level of an autonomous organ, which while located on the receptacle surface is not an inherent part of its development.

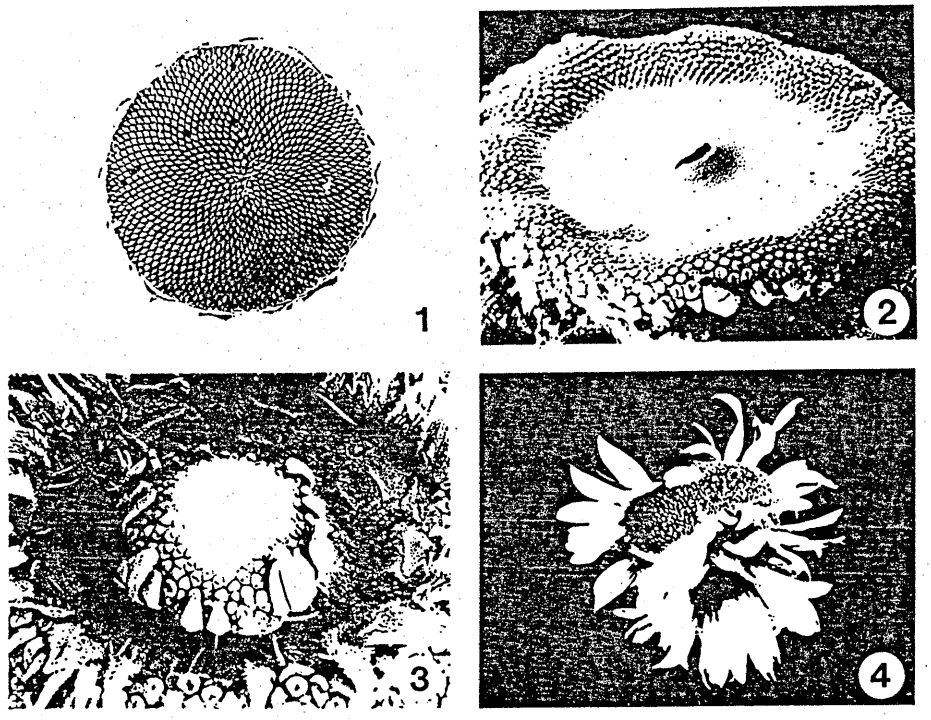

Fig. 1. Mature head showing organisation of seeds into left and right turning spiral rows which conform to the Fibonacci system.

Fig. 2. SEM of receptacle of hybrid NS44, 8 days after application of benzyladenine. Showing increased production of floret initials and floret rows and loss of Fibonacci row organisation. Receptacle diameter 6.0 mm.

Fig. 3. Development of the plug after 8 days. Showing involucral bracts at the plug rim and the formation of rows of disc floret initials. Plug diameter, 2.3 mm.

Fig. 4. Miniature capitulum regenerated from the plug.

ACKNOWLEDGEMENT

L F Hernández is supported by a scholarship from the Consejo Nacional de Investigaciones Científicas y Técnicas, (CONICET), Argentina.