FOLIAR APPLICATION OF CYTOKININS INCREASED REPRODUCTIVE GROWTH EFFICIENCY AND YIELD OF THE SUNFLOWER

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SUMMARY

Two sunflower cultivars (Dekalb G90 and Dekalb G100) grown under furrow irrigation in the semiarid Argentine region (62°11' W; 38°44' S) were tested for their growth and yield responses to externally applied cytoquinins. At an early stage of capitulum formation (FS §* 1) chosen plants in the crop were sprayed using ethanolic solutions (100 ppm of the active ingredient) of the plant growth regulators (PGR) BA ([6-(Benzylamino purine)]) or Promalin (Cytokinin + Gibberellin A_{3+7}). During crop growth the number of growing floret primordia per plant was counted. After harvest, the total aerial biomass and yield was determined.

The application of PGR significantly expanded the meristematic surface of the receptacle in both cultivars, hence increasing the number of floret primordia on the differentiated capitulum and the grain yield per plant. Selectivity between PGR and cultivar was observed, being more effective the combination G100+BA (32% grain yield increase) and G90+Promalin (41% grain yield increase). Floret abortion was observed in the central region of the capitulum in 35% of the plants treated. This was attributed to a toxic effect produced by the PGR applied. However, it also could suggest that the cultivars tested would not be able to supply efficiently photoassimilates to the capitulum under the increased sink demand of a surplus of growing fruits.

INTRODUCTION

The total number of floret primordia developed in the sunflower capitulum is a genotypic characteristic directly related with the maximum size attained by the meristematic surface of the empty receptacle (Hernández and Palmer, 1988) and with the generative area duration (Palmer and Steer, 1985).

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*§ FS : Floral stage in the sunflower using the ten-stage classification of Marc and Palmer, (1981).

It has been shown that the external application of the plant growth regulator Benzyladenine (BA) at low concentrations, results in a significant increase of the number of fertile flowers at anthesis (Hernández, 1988; Palmer and Hernández, 1988). This is a consequence of a large expansion of the meristematic surface of the receptacle before the initiation of floret primordia takes place. This evidence leads us to postulate that it is possible to control systematically the number of floret primordia in the capitulum, an important parameter in the determination of yield, particularly for physiological studies or breeding purposes (Palmer and Hernández, 1988). This paper reports the results obtained applying cytokinins to evaluate the yield response of the sunflower crop under field conditions.

MATERIALS AND METHODS

Plant cultivation: Sunflower plants cv. Dekalb G100 (short season, 50-55 days from emergence to anthesis) and cv. Dekalb G90 (long season, 58-60 days from emergence to anthesis) were grown on a sandy soil at Bahía Blanca (Argentina, 38°44' S Lat. and 62°11' W Long.). The crop was planted on the 15th of November and kept at a density of 5.6 plants m^{-2} (30 cm between plants and 60 cm between rows). The plants were furrow-irrigated, fertilized twice using superphosphate and potassium nitrate (60 and 50 Kg Ha^{-1} respectively) and sampled periodically to evaluate its developmental status following the ten stage classification developed by Marc and Palmer (1981).

Application of plant growth regulators: N^6-Benzyladenine (BA) (Sigma, USA) and Promalin ([Cytokinin (N-(Phenil-methil)- 1H-Purine-6- Amine) (1.8% w/w) + Gibberellins A_{3-7} (1.8% w/w)], Abbot Laboratories, USA) were used. BA was sprayed using an ethanolic solution (30 % v/v) at a concentration of 100 ppm. Promalin was sprayed using the same ethanolic solution and at a concentration of 100 ppm of the active ingredient of each compound. In every application each plant received 5-6 ml of each solution.

Description of the treatments: **BA1** and **PRO1**: Application of 6-Benzyladenine (**BA**) or Promalin (**PRO**) 19 days from seedling emergence (FS 1). **BA2** and **PRO2**: Application of 6-Benzyladenine (**BA**) or Promalin (**PRO**) 19, 23, 27 and 31 days from seedling emergence (FS 1, 3 and 5 respectively) **CONTROL**: External application of an ethanolic solution (30% (v/v)) 19 days from seedling emergence (FS 1).

Measurements: During capitulum formation the rate of reproductive development (RRD = units of floral stage . day^{-1}) was calculated. The total number of floret primordia developed at the end of the period of primordia formation (40-45 days from emergence) was also measured. The experiment was organized in a completely randomized design with 6 replicates per treatment.

RESULTS AND CONCLUSION

Promalin applied only once at the beginning of FS 1 (19 days after emergence) produced a significant increment on grain yield with values that ranged between 14.5 % for G100 and 41% for G90 (Figure 1a-b, Table 1). BA was effective also when applied only once at the beggining of receptacle formation (FS 1) producing an increment of 32 % in G100. BA and Promalin also induced an increase of the shoot dry weight of the plants treated, which was directly related to the relative increases observed in grain yield (Table 1).

PGR also produced a similar effect on the total number of floret primordia developed in the capitulum. Values up to 60 % increase in the total number of floret primordia were determined (Table 1). The consecutive application of PGR for more than two weeks (treatments BA2 and PRO2) produced a reduction or no significant changes in grain yield (Table 1). More than one application produced undesirable effects in the plants. It was observed in the field that 35 % of the plants treated, particularly in the combinations BA2-G100, PRO2-G90 and PRO2-G100 presented symptoms of toxicity in the ray flowers and involucral bracts at anthesis. Also, floret abortion in the central region of the capitulum during the grain filling period was observed in 33 % of the plants treated. This can be attributed to a deficient supply of photoassimilates on the central region of the capitulum, probably induced by an enhanced sink demand of a surplus of growing fruits. Abnormalities in vascular connections a the center of large capitula have been reported by Durrieu et al. (1985) and observed by Hernández (1988).

Although the crop never was under water stress, the positive relation found between the increase in shoot dry weight and grain yield (Table 1) suggest that the contribution of dry matter from the shoot can be significant. This agree with that reported by Cadeac (1988) and postulated by Hall *et al.* (1989).

Many alternatives can be postulated to achieve increments in the yield potential of the sunflower crop. One of them could be to obtain cultivars with a more extended period of floret formation. The results reported here add a faster and practical technique that can be used by plant breeders or physiologists to artificially manipulate the potential number of floret primordia in the plant and may contribute to improve the crop productivity.

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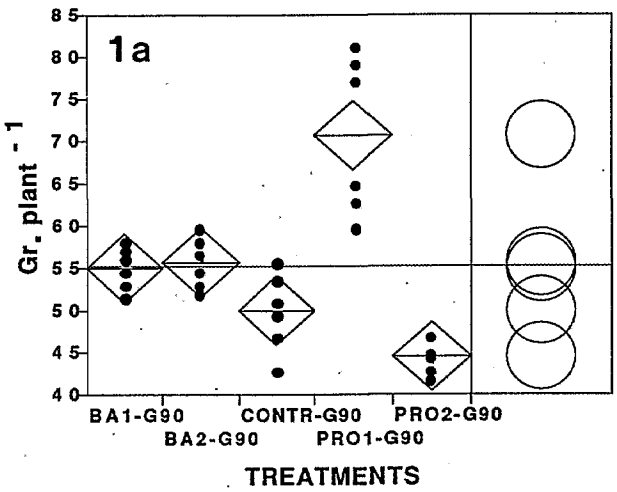

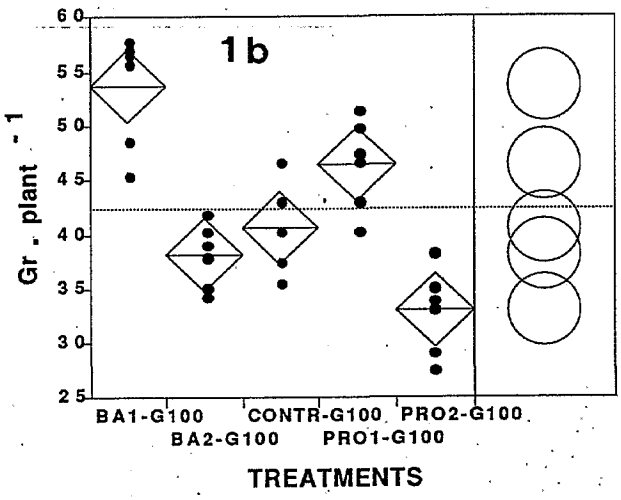

Figure 1: Grain yield (g.plant^{-1}) of the plants treated with the PGR Benzyl- adenine (BA1 and BA2) or Promalin (PRO1 and PRO2) and control (CONTR). Comparison circles at the side of ecah figure show significance among a set of means. If the circles for two means do not intersect then the means are different (confidence level : 95%). **1-a:** cv. Dekalb G90; **1-b:** cv. Dekalb G100. Statistical analysis was made using the SAS-JMP™ software for the Apple Macintosh ™ Computer.

Table 1: Shoot dry weight, grain yield and number of floret primordia developed in the plants of the hybrid cultivars tested in the experiment.

Treatment	Shoot dry weight (g)	Dif % (1)	Yield (g.plant^{-1})	Dif %	Floret primordia (2)	Dif %
BA1-G90	72.5	+ 2.26	55.1	+ 9.76	891	+ 22.7
BA2-G90	65.1	- 8.18	55.8	+ 11.16	917	+ 26.3
PRO1-G90	101.9	+ 43.72	70.8	+ 41.04	1097	+ 51.1
PRO2-G90	55.3	- 22.00	44.7	- 10.97	706	- 2.7
control G90	70.9	-	50.2	-	726	
BA1-G100	85.2	+ 38.67	53.7	+ 31.94	1372	+61.0
BA2-G100	56.9	- 7.33	38.1	- 6.39	975	+14.4
PRO1-G100	70.5	+ 14.82	46.6	+ 14.50	923	+ 8.3
PRO2-G100	51.4	- 16.33	32.9	- 19.16	763	- 11.6
control G100	61.4	-	40.7	-	852	-

(1): Difference (%) with the control. (2): Total floret primordia per capitulum in Floral Stage 8

REFERENCES

CADEAC, F. 1988. Correlation entre le diametre de la tige et la production d'akenes chez le tournesol. XII International Sunflower Conference Proceedings, Novi Sad. pp. 198-202.

DURRIEU, G., PERCIE DU SERT, C. and MERRIEN, A. 1985. Anatomie du capitule de tournesol. Consequences sur la nutrition des akenes. XI International Sunflower Conference Proceedings, Mar del Plata. pp. 7-12.

HALL, A.J., CONNOR, D.J. and WHITFIELD, D.M. 1989. Contribution of pre-anthesis assimilates to grain filling in irrigated and water-stressed sunflower crops. I. Estimates using labelled carbon. Field Crops Research, 20: 95-112.

HERNANDEZ, L.F. 1988. Organ Morphogenesis and Phyllotaxis in the Capitulum of Sunflower (Helianthus annuus L.). Ph.D. Thesis. University of New South Wales, Australia, 217 pp.

HERNANDEZ, L.F. and J.H. PALMER. 1988. A computer model to create the Fibonacci floret pattern of the sunflower head. XII International Sunflower Conference Proceedings, Novi Sad, pp. 150-155.

MARC, J. and PALMER, J.H. 1981. Photoperiodic sensitivity of inflorescence initiation and development in sunflower. Field Crops Research. 4: 155-164.

PALMER, J.H. and STEER, B.T. 1985. The generative area as the site of floret initiation in the sunflower capitulum and its integration to predict floret number. Field Crops Research 11: 1-12.

PALMER, J.H. and HERNANDEZ, L.F. 1988. Techniques to change the number of floret and seed rows in the sunflower capitulum. XII International Sunflower Conference Proceedings, Novi Sad, pp. 156-157.