Genetics and Molecular Biology, 23, 1, 221-222 (2000)

Short Communication

Genetic analysis of a cross of gaillon (*Brassica oleracea* var. *alboglabra)* with cauliflower (*B.oleracea* var. *botrytis*)

Vanessa B.M.G. Spini and Warwick Estevam Kerr

Abstract

The cauliflower (*Brassica oleracea* var. *botrytis*) is an annual vegetable cultivated in Southern and Southwestern Brazil with limited production in the Northeast and Centralwest. A variety of Chinese kale, "kaai laan" or "gaillon" (*Brassica oleracea* var. *alboglabra*), produces seeds at high temperatures and therefore can do so in North and Northeastern Brazil. Gaillon and cauliflower were crossed 55 times using 10 gaillon plants as mothers and 4 cauliflower plants as pollen donors. From these crosses, in the F2 generation, 612 plants with inflorescence like gaillon and 48 plants with inflorescence like cauliflower were obtained, in a proportion similar to 15:1, implying that 2 pairs of genes entered into formation of the cauliflower inflorescence type. In order to study flower color, 339 plants were analyzed: 274 presented white flowers and 65, yellow flowers, denoting that this caracter is determined by 1 pair of genes, white being dominant over yellow; white flowers had a slighly higher adaptive value in our population. The characteristic waxy leaf showed a proportion of 3 waxy plants for 1 not waxy, indicating the action of one pair of genes.

INTRODUCTION

The species *Brassica oleracea* belongs to the Brassicaceae family and presents many economically important botanical varieties among which are cauliflower, kale, cabbage, broccoli, turnip cabbage, butter cabbage and Brussel sprouts. Besides offering both quality and quantity of nutrients (Siqueira, 1981; Zhang *et al*., 1994), several epidemiological studies have demonstrated that consumption of vegetable, specially of the Brassicaceae family, like broccoli and cauliflower, reduces risk cancer in several organs (Zhang *et al.*, 1992, 1994). According to Dr. Paul Talalay and his group, sulforaphane [1-isothiocyanato-4-(methyl-sulfinyl) butane], isolated from broccoli "Saga Broccoli", induces production of enzymes that metabolize xenobiotics and decreases toxicant effects, mutagenics and chemical carcinogenics (Prochaska *et al.*, 1992; Zhang *et al.*, 1992, 1994).

The 'Early Summer Piracicaba' cauliflower is a less cultivated tropical cauliflower, but good for hot climates. If planted from December to March it produces 30-40% defective heads, with internal dark bluish bracteas, reducing its market value. In the Northeast, where high temperatures prevail 24 h a day, this vegetable, besides producing defective heads, does not produce seeds, resulting in dependence on the South for seed production. In 1988, we received seeds of *Brassica oleracea* var. *alboglabra*, the gaillon or "kaai laan"of China. The great advantage of this subspecies is seed production at high temperatures (27° to 35°C), unusual for cauliflower. With daily temperature reaching 35°C and hot nights, seed production of most Brassicas is affected, reducing leaf size and resulting in precarious development of cauliflower heads in particular (Ferreira, 1983). The gaillon is an annual plant, with small, flat, green-bluish oval and petiolated leaves; it has long inflorescence, with green flower buds, similar to the broccoli, and white flowers.

MATERIAL AND METHODS

The experiment was carried out in the experimental area of the Federal University of Uberlândia, Campus Umuarama, Uberlândia, MG, Brazil, 931 m altitude and coordinates 18° 53' 10''S and 48° 15' 45'' W. Donated in 1992 by Prof. Norberto Silva (UNESP, Botucatu), the gaillon seed originated in Chinatown, CA, USA, while the Early Summer Piracicaba cauliflower came from local suppliers.

The two varieties of *B. oleracea* were sowed in trays and maintained in a greenhouse until the transplant to the field (about 30 days post-sowing). Culture conduction included three fertilizations using ammonium sulfate and fortnightly spraying with 0.2% Borax until inflorescence formation.

Crossings for obtaining hybrids were carried out in June 1995 and done manually using forceps, brushes and probes. The anthers were eliminated (female, gaillon) and stigmas were powdered with cauliflower, using a brush. After each crossing the flower buds were covered with organza sacks, to prevent cross-fertilization by bees. Ten *Brassica oleracea* var. *alboglabra* plants and four *Brassica oleracea* var. *botrytis* plants were used, totaling 55 crossings. Those cross seeds were mixed to form generation F1.

Departamento de Genética e Bioquímica, Universidade Federal de Uberlândia, 38400-902 Uberlândia, MG, Brasil.
Send correspondence to V.B.M.G.S. E-mail: warwick@umuarama.ufu.br

The F1 plants formed two groups: 1) plants with central head exceeding 10 cm in diameter, marble flower buds, with little or no leaves in the head, and butter kale type soft leaves; 2) plants with small center head and sproutings like gaillon, with butter kale type soft leaves.

These plant seeds were mixed to form generation F2, whose plants can also be roughly divided into three populations: 1) gaillon-like plants, with central head exceeding 10 cm, small floral buds with little or no sprouting and butter kale type soft leaves; 2) gaillon-like plants, with small central head and abundant sprouting, with butter kale type soft leaves; 3) cauliflower-like plants, white or slightly greenish, with a single head diameter exceeding 15 cm, and butter kale type soft leaves.

All F2 plant seeds were mixed to form generation F3. The cross-pollination was made intensely both by the stingless bee *Trigona spinipes* and by the Africanized *Apis mellifera*.

RESULTS

The cross between gaillon and cauliflower (F1) resulted in 80 plants, 100% with gaillon inflorescence. Of these 80 plants, 34 were discarded due to termite attack. The remaining 46 plants presented gaillon type heads, with diameter exceeding 10 cm, with greenish-blue soft leaves, similar to the butter kale; 100% of the plants presented white flowers, like the gaillon. The F1 plants were left to produce seeds for analysis of segregation in F2.

The F2 generation produced 804 plants and 660 developed heads: 612 like gaillon and 48 like cauliflower. The cauliflower-like heads in the beginning were light, white or cream color, becoming greenish or violaceous.

To characterize flower color, 211 plants were analyzed; 169 presented white flowers, like the gaillon, and 42 yellow flowers, like the cauliflower. As for leaf appearance of 461 plants analyzed, 361 plants presented waxy leaves and 100 plants presented no waxy leaves.

DISCUSSION

The inflorescence-like characteristic separated 15 plants with gaillon-like head from 1 plant with cauliflower-like head demonstrating determination by 2 gene pairs (χ^2 = 1.15) and double epistasy interaction. For flower color segregation was monofactorial 3:1, denoting determination by 1 gene pair (χ^2 = 2.93), with white dominant over yellow. White flowers (w = 1) showed a slightly higher adaptive value over yellow (w = 0.8). The waxy leaf characteristic showed a proportion of 3 waxy plants to 1 not waxy, showing the action of one gene pair (χ^2 = 2.9).

Although we were specifically interested in plants with inflorescence of the cauliflower type, plants with gaillon-like inflorescence, very similar to the broccoli, were also selected since they presented soft butter kale-like leaves allowing total use of the vegetable. The seeds of the best F2 plants are currently being put to a new cycle of selection. Genetic bifactorial interaction is very common in plants. In this experiment epistatic interaction appeared in three cases.

ACKNOWLEDGMENTS

Acknowledgments are due to the Federal University of Uberlândia for use of its infrastructure. Dr. Norberto da Silva supplied the gaillon seeds; Francisco Raimundo da Silva and João Paiva dos Reis provided technical assistance in the field. The National Council of Scientific and Technological Development (CNPq) granted both a scholarship to the first author and a research grant to the second.

RESUMO

A couve-flor (*Brassica oleracea* var. *botrytis*) é um vegetal anual e tem seu cultivo no Brasil limitado às regiões Sul e Sudeste, com pequena produção no Nordeste e Centro-Oeste. Uma variedade de couve da China, "kaai laan" ou "gaillon" (*Brassica oleracea* var. *alboglabra*), produz sementes em altas temperaturas e, portanto, é apta a produzir sementes no Norte e Nordeste do Brasil. Gaillon e couve-flor foram cruzados. Foram feitos 55 cruzamentos usando 10 plantas de gaillon como mãe e 4 plantas de couve-flor como doadores de pólen. Desses cruzamentos, na geração F2, 612 plantas com inflorescência tipo gaillon e 48 plantas com inflorescência tipo couve-flor foram obtidas, em proporção similar a 15:1, demonstrando que 2 pares de genes estão envolvidos na formação da inflorescência em couve-flor. Com o objetivo de estudar a cor das flores, 339 plantas foram analisadas: 274 apresentaram flores brancas e 65 flores amarelas, demonstrando que este caráter é determinado por 1 par de genes, sendo branco dominante sobre amarelo; as flores brancas têm um valor adaptativo levemente maior em nossa população. O caráter cerosidade da folha mostrou uma proporção de 3 plantas cerosas para 1 planta não cerosa, que mostra a ação de 1 par de genes.

REFERENCES

Ferreira, F.A. (1983). Efeito do clima sobre as Brássicas. Belo Horizonte. *Inf. Agropec. 9*: 12-14.

Prochaska, H.J., Santamaria, A.B. and **Talalay, P.** (1992). Rapid detection of inducers of enzymes that protect against carcinogens. *Proc. Natl. Acad. Sci. USA 89*: 2394-2398.

Siqueira, T. da S. (1981). Brássicas. In: *Cultura de Brássicas*. U.F. Viçosa, Viçosa, pp. 1-14.

Zhang, Y., Talalay, P., Cho, Cheon-Gyu and **Posner, G.H.** (1992). A major inducer of anticarcinogen protective enzymes from broccoli: Isolation and elucidation of structure. *Proc. Natl. Acad. Sci. USA 89*: 2399-2403.

Zhang, Y., Kensler, T.W., Cho, Cheon-Gyu, Posner, G.H. and **Talalaya, P.** (1994). Anticarcinogenic activities of sulforaphane and structurally related synthetics norbonyl isothiocyanates. *Proc. Natl. Acad. Sci. USA 91*: 3147-3150.

(Received May 4, 1999)