Inhibitory Effect of Abscisic Acid on Shoot Growth and Flowering Induced by Gibberellic Acid in Nonprecooled Derooted Bulbs of Tulip (Tulipa gesneriana L.)

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Inhibitory Effect of Abscisic Acid on Shoot Growth and Flowering Induced by Gibberellic Acid in Nonprecooled Derooted Bulbs of Tulip (*Tulipa gesneriana* L.)

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Effect of gibberellic acid (GA_3) at a concentration of 200 mgl^{-1}, abscisic acid (ABA) at a concentration of 20 mgl^{-1} and their mixture on shoot growth and flowering in nonprecooled derooted tulip bulbs cv. Apeldoorn was investigated. As it was found previously GA_3 induced shoot growth and flowering in nonprecooled derooted bulbs of tulip. The present studies showed that the simultaneous application of GA_3 with ABA totally inhibited shoot growth and flowering induced by the gibberellin in nonprecooled derooted tulip bulbs. These results suggest that hormonal balance, gibberellins–abscisic acid, is the important factor in control of dormancy and dormancy release of tulip bulbs, causing shoot growth and flowering.

INTRODUCTION

It is well known that during the cooling of the tulip bulbs the amount of free gibberellins increases (Aung and De Hertogh, 1967; 1968; De Hertogh *et al.*, 1971; Van Bragt, 1971; Aung and Rees, 1974; Hanks and Rees, 1980). Exogenously applied gibberellins cannot substitute for cold treatment of nonprecooled tulip bulbs but do for only partially cooled bulbs and stimulate shoot growth and flowering (Van Bragt and Zijlstra, 1971; Rudnicki *et al.*, 1976; Van Bragt and Van Ast, 1976; Cocozza Talia and Stellacci, 1979; Hanks, 1984; 1985; Jones and Hanks, 1984). Saniewski *et al.* (1999) showed that in nonprecooled derooted bulbs flower bud blasting occurred and no growth of stem was observed but GA_3 greatly induced shoot growth and flowering. The stimulatory effect of gibberellin on shoot growth and flowering in nonprecooled derooted bulbs was much stronger than in case of nonprecooled rooted bulbs (Rudnicki *et al.*, 1976). Kawa and Saniewski (1986) showed that gibberellic acid had a strong stimulatory effect in increasing the length and fresh weight of pistil isolated from nonprecooled tulip bulbs but to a lesser degree in the case of cooled bulbs, cultured in vitro.

The presence of abscisic acid in tulips is well documented (Syrtanova *et al.*, 1975; Aung and De Hertogh, 1979; Singh *et al.*, 1979; Terry *et al.*, 1982) and low temperature treatment decreases the amount of ABA (Syrtanova *et al.*, 1973; Rakhimbayev *et al.*,

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1978; Aung and De Hertogh, 1979).

In the present study the inhibitory effect of abscisic acid on tulip shoot growth and flowering induced by gibberellic acid in nonprecooled derooted tulip bulbs is documented.

MATERIALS AND METHODS

Tulip bulbs cv. Apeldoorn, with a circumference of 10–11 cm, after lifting were stored at 18–20 °C until the end of October and then were stored at 17 °C until used for experiments on January 22 (nonprecooled bulbs). After removal of dry scales all roots were excised and bulbs were kept on petri dishes in following solutions of growth regulators: 1) control, distilled water only, 2) GA_3 at a concentration of 200 mgl^{-1}, 3) ABA at a concentration of 20 mgl^{-1}, and 4) GA_3+ABA in above concentrations.

Fifteen bulbs per treatment were used and newly appeared roots were removed daily. The solutions were changed every 2 or 3 days. On February 12 all treatments were replaced by distilled water. During the first two weeks of experiment the length of sprouts (to the top of first leaf) were measured. The length of all internodes and leaves were recorded on February 8 and February 24, when experiment ended. The length of the first (basal) internode was measured from the basal plate to the first leaf node and the fourth internode from the third leaf to the base of the flower, after the scales from 5 bulbs per treatment were removed.

On January 22, 20 intact nonprecooled tulip bulbs (storage conditions are presented above) and 20 bulbs dry cooled at 5 °C from October 15 were individually planted in the pots (after removal of dry scales), for comparison their growth and development.

The data were subjected to an analysis of variance and the Duncan's t–test was used to estimate the difference between means at P=0.05.

RESULTS AND DISCUSSION

The shoot growth of nonprecooled derooted tulip bulbs was very small and only sprouting of leaves was observed and flower bud blasting took place (Figs. 1, 2, 3). As it was found previously, GA_3 at a concentration of 200 mgl^{-1} stimulated sprouting and finally induced shoot growth and caused flowering (Figs. 1, 2, 3). Both the growth of stem and all leaves was evidently stimulated by GA_3 (Fig. 3). Abscisic acid applied alone inhibited sprouting of nonprecooled derooted tulip bulbs (Figs. 1, 2) and it was caused through inhibition of growth of all intact leaves (Fig. 3). Since in the control – nontreated nonprecooled derooted tulip bulbs, the growth of stem was very small, the effect of ABA applied alone on its growth was not possible for observation (Figs. 2, 3). However, simultaneous application of GA_3 and ABA showed that abscisic acid greatly inhibited shoot growth (stem and leaves) and flowering induced by gibberellic acid in nonprecooled derooted tulip bulbs (Figs. 2, 3).

It should be mentioned that nonprecooled tulip bulbs used in our experiments were in deep dormancy stage since after planting of the intact bulbs (with roots) only small sprouting took place and no shoot growth was observed but in cooled bulbs normal growth and development of shoot occurred (Fig. 4).

Leaf explants isolated from nonprecooled tulip bulbs and cultured on

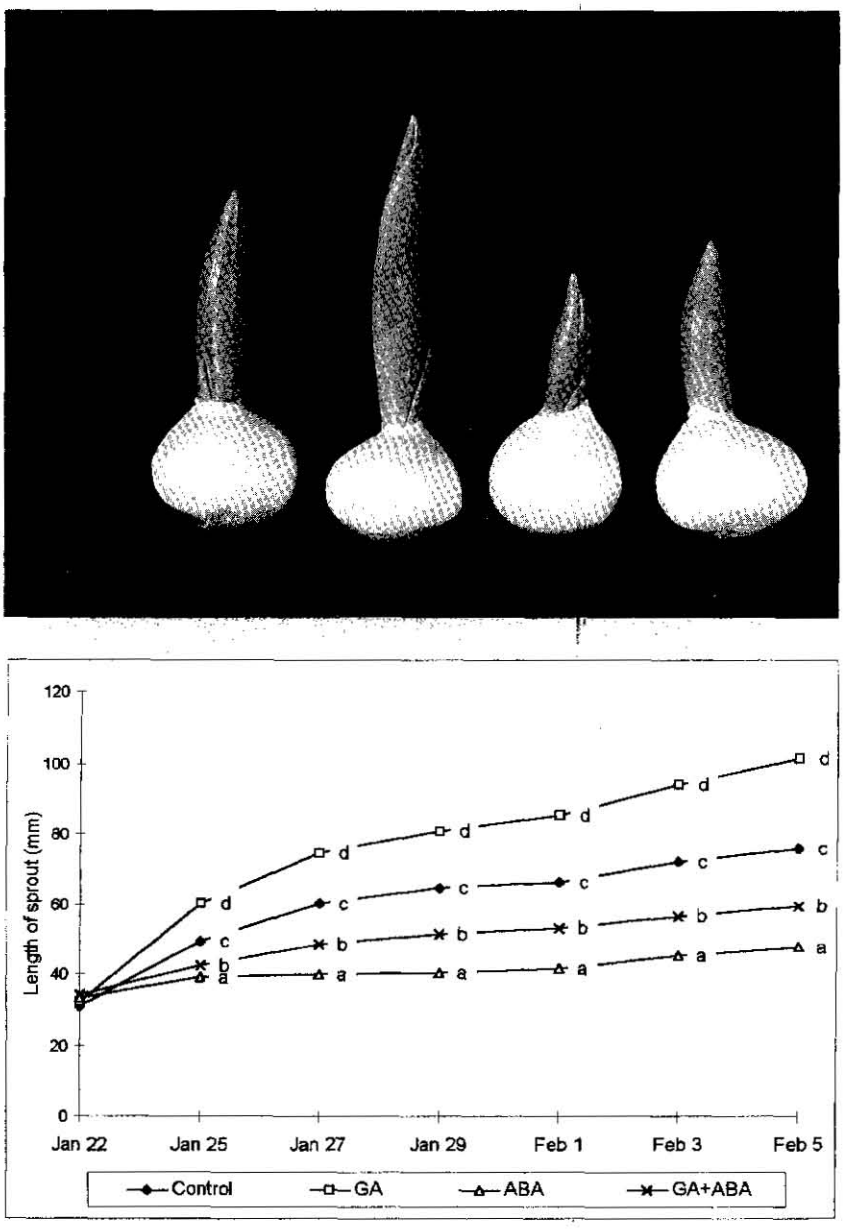

Fig. 1. Effect of GA_3 200 mgl^{-1}, ABA 20 mgl^{-1} and their mixture on sprouting of shoots (leaves) of nonprecooled derooted bulbs cv. Apeldoorn. Treatments were made on January 22. The photograph (Upper. Left to right: control, GA_3, ABA and GA_3+ABA) was taken on February 4 and the length of sprouts was measured from beginning of experiment until February 5 (Lower). Different letters indicate significant differences according to Duncan's t-test (P=0.05), values are calculated separately for each day of measurements.

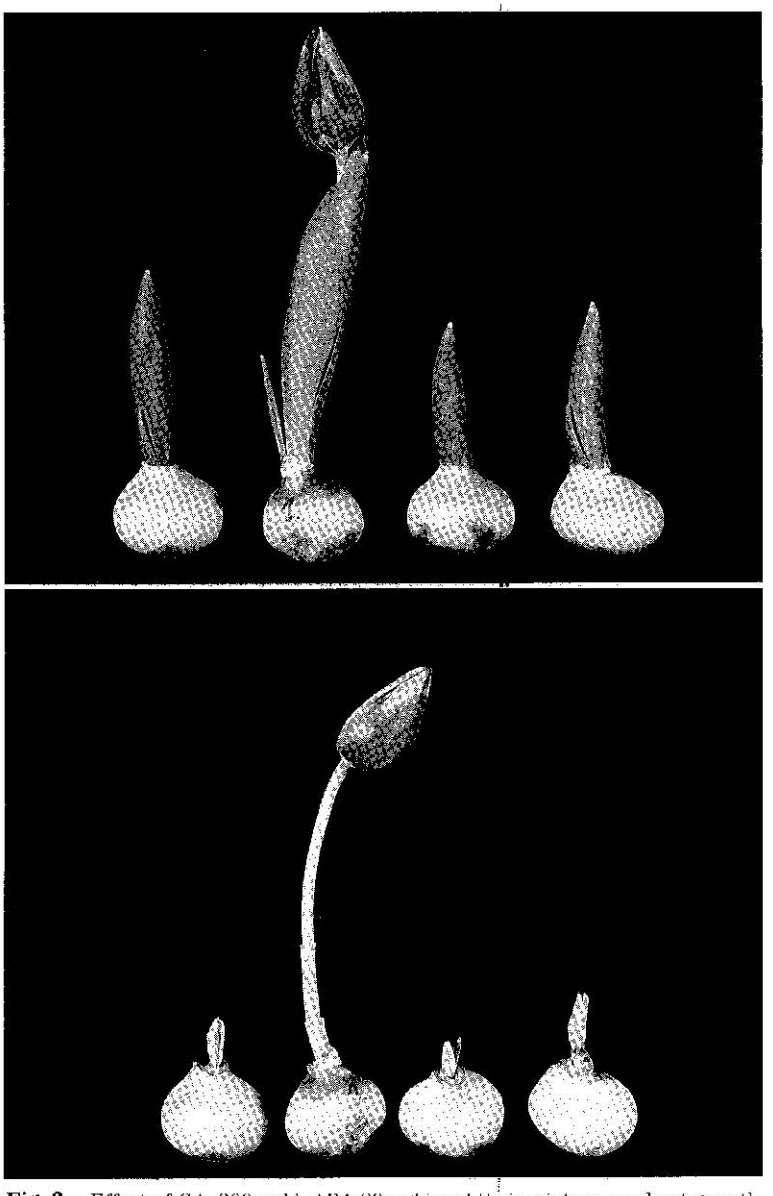

Fig. 2. Effect of GA_3 200 mgl^{-1}, ABA 20 mgl^{-1} and their mixture on shoot growth and flowering of nonprecooled derooted bulbs cv. Apeldoorn. Treatments were made on January 22 and the plants were photographed on February 23, either with leaves (Upper) or after removal of all leaves before photography (Lower). From left to right: control (distilled water) – no growth of stem and flower bud blasting can be observed, GA_3 – stimulatory effect on shoot growth and flowering, ABA – no growth of stem and flower bud blasting, GA_3+ABA – inhibitory effect of ABA on stem growth and flowering induced by GA_3.

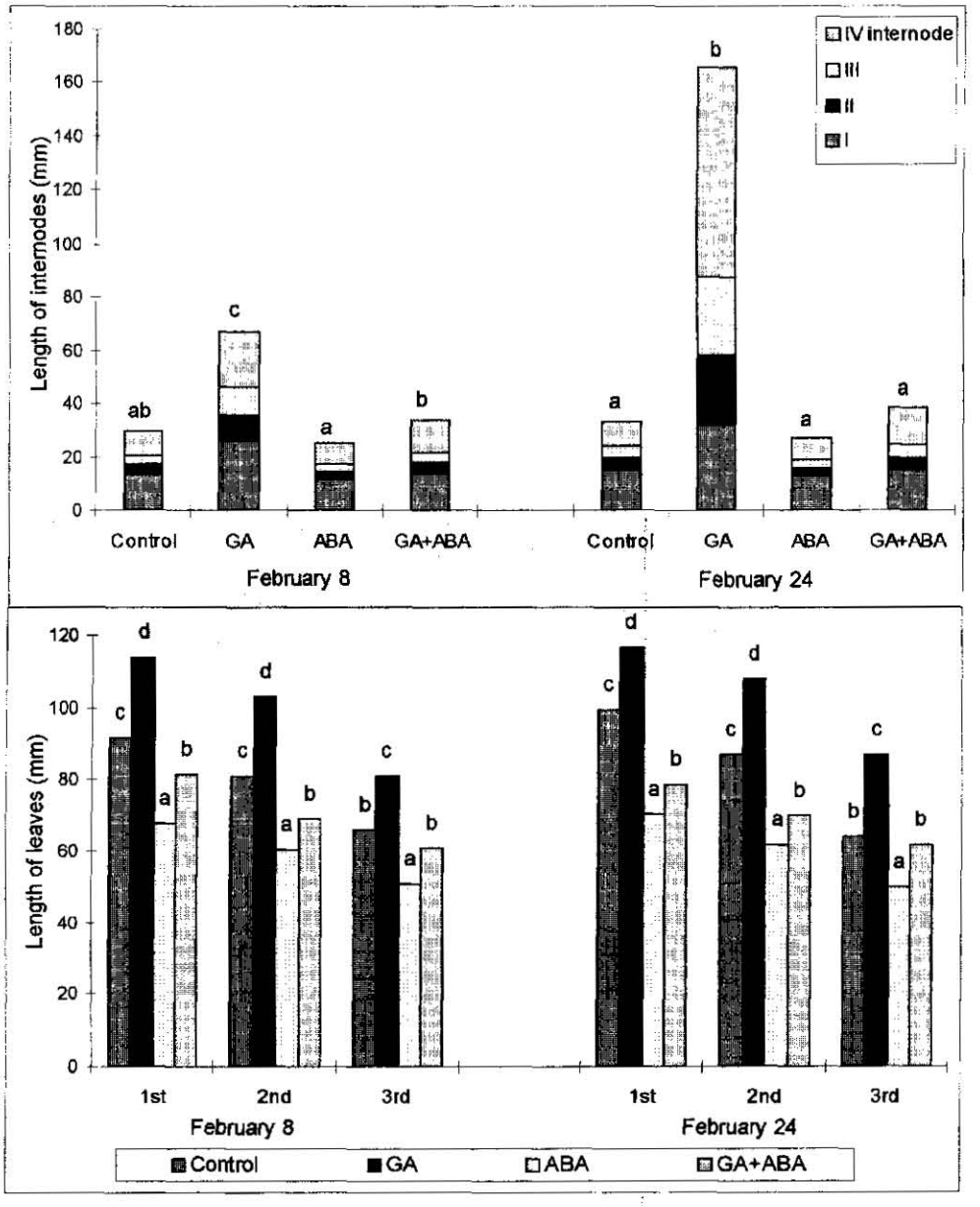

Fig. 3. Effect of GA_3 200 mgl^{-1}, ABA 20 mgl^{-1} and their mixture on stem (Upper) and leaves (Lower) growth of nonprecooled derooted bulbs cv. Apeldoorn (see Fig. 2). Treatments were made on January 22 and the measurements were made on February 8 and 24. Different letters indicate significant differences according to Duncan's t–test (P=0.05), values are calculated separately for each day of measurements; for total stem length (Upper) and separately for each leaf (Lower).

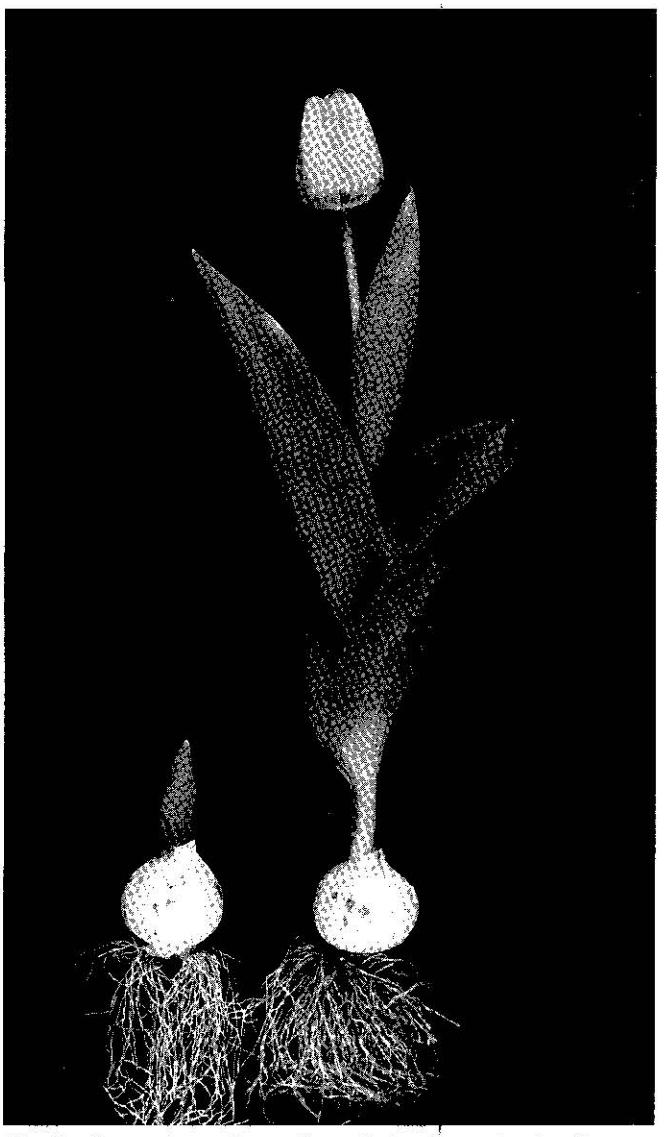

Fig. 4. Comparison of growth and development of tulips cv. Apeldoorn after planting of nonprecooled (Left) and cooled (Right) bulbs. Bulbs were planted on January 22, photographed on February 10.

Murashige–Skoog (MS) medium (without plant growth regulators) showed slight growth, however, the addition of gibberellic acid to the medium substantially stimulated an increase of length and fresh and dry weight of the explants, cultured in both normal and inverted positions (Kawa and Saniewski, 1990a). The growth of leaf explants isolated

from uncooled bulbs and stimulated by GA_3 was greatly inhibited by simultaneous application of ABA to the medium (Kawa and Saniewski, 1990a). The growth of stem explants (in inverted position), isolated from uncooled and cooled tulip bulbs and induced by auxin (IAA), was also inhibited by ABA applied to the medium together with the auxin (Saniewski and Gabryszewska, 1983; Kawa and Saniewski, 1990b). Thus, it seems that the presence of ABA in uncooled bulbs would inhibit the growth of stem and leaves and keep in dormancy the tulip bulbs. Aung and De Hertogh (1979) suggested that probable sites of abscisic acid biosynthesis in tulip bulbs are the developing bulblets, basal plate and roots, since the ABA level is high in these organs and low in scales and shoot.

The results of present studies showing the inhibitory effect of ABA on shoot growth and flowering induced by GA_3 in nonprecooled tulip bulbs suggest that the hormonal balance, abscisic acid – gibberellins, is the most important factor in control of dormancy release of tulip bulbs, causing shoot growth. The shoot growth is controlled by interaction of auxin with gibberellins as was suggested previously (Okubo and Uemoto, 1985; 1986; Okubo *et al.*, 1986; Saniewski, 1989).

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