FW data of cuttings from all the plant species grown under SD the FW was less than from plants under the light treatments (Table 3).

The growth response to the alternation of SD and photoperiod treatments on a 10, 20 or 30 day basis as observed in Experiment II can be compared to work on the number of cycles needed to induce flowering under SD (Table 4). This was observed in *Glycine max* (15). We propose that there exists a critical number of light cycles (CNLC) for both flower promotion and lateral branching. In the case of *Pilea* it appears that the CNLC for branching is shorter than the CNLC for flower induction. The CNLC necessary for branching can easily be overlooked, since most CNLC studies to date have dealt with flowering (15). Also for many species used in these experiments (i.e. *Pilea,* Table 4) the photoperiod that promotes flowering is the opposite of that which promotes vegetative or lateral growth. Thus, additional work needs to be done to determine that CNLC needed for branching in many horticulturally important species.

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Light and Gibberellic Acid Enhancement of Lowbush Blueberry Seed Germination[1]

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Abstract. **A light requirement for improved seed germination of lowbush blueberry (*Vaccinium angustifolium* Ait.) was partially overcome by GA treatments; GA at 500, 1000, 2000, and 4000 ppm stimulated early germination of seeds kept in the dark. The germination rate of seeds exposed to an 8 hour light period was also enhanced by GA treatments. Continuous exposure to concentrations above 1000 ppm resulted in abnormally curled seedlings with necrotic root tips.**

Plant breeders have been inconvenienced by low and erratic blueberry seed germination for many years (1, 2, 4, 10, 11). More recently, attempts to establish commercial lowbush blueberry plantings by seed have been impeded by germination difficulties (J. Sibley, personal communication).

Lowbush blueberry (*Vaccinium angustifolium* Ait.) seed requires no rest period for germination (8). Seed can be stored satisfactorily at −23°C., either in fruit or as dried seeds (1). Germination begins in 3 to 4 weeks (7), but can be quite sporadic, often requiring 6-8 weeks for complete germination. Lowbush blueberry seed germination is also inconsistent between seed lots. These problems are not unique to the lowbush blueberry, as delay in germination and inconsistent germination also seem to be perennial problems of highbush blueberry breeders (4). A light requirement for germination has been demonstrated for highbush blueberry (*Vaccinium corymbosum* L.) (10, 11), rabbiteye blueberry (*Vaccinium ashei* Read cv. Tifblue) (2), and cranberry (*Vaccinium macrocarpon* cv. Early Black) (5).

ABA may be a controlling factor in cranberry seed germination with light and possibly GA negating its effect (6). While GA_3 had no effect on rabbiteye blueberry seed, GA_{4+7} stimulated early germination and hastened seedling transplanting by 2 to 4 weeks (4).

The following studies were conducted to determine if the lowbush blueberry has a light requirement and to determine the effect of GA on germination in the light in the dark.

Materials and Methods

Study 1. Open pollinated seed of clone 2827, which were

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harvested in August, 1974, and refrigerated at 4°C. in the fruit for 6 weeks, were extracted using the method of Morrow et al. (9). Seeds, which passed through a sieve having 1 mm holes but not a sieve with 0.5 mm holes, were further sorted using a general seed blower (New Brunswick General Sheet Metal Works, Highland Park, N.J.). With the blower gate set at 15 and air ports 1 and 2 closed, the largest of the air blown seeds were selected and divided into lots of 100 seeds each. The 100-seed lots were germinated in Petri dishes on 2 layers of blotter paper saturated with 20 ml of the treatment solutions (0, 50, 100, 500, 1000 ppm GA). A 4 block randomized complete block, split plot design was employed with light vs. dark by GA concentration as the main treatments and date of germination the subtreatments.

Petri dishes were placed in a Stults Germinator (Model No. 12677) which maintained 25°C under Cool White fluorescent light (.002-.006 cal/cm^2-min) for 8 hr followed by 15°C and darkness for 16 hr. Dark treatments were imposed by wrapping Petri dishes in aluminum foil. Petri dishes were examined for radicle emergence, the criterion for germination (3) after 13 days and at 2 day intervals until the 27th day. Germination readings were discontinued after the 27th day due to fungal contamination.

Study 2. Fruit from Clone 51010 were harvested in August 1975 and stored frozen for 6 months. The open pollinated seed were extracted in the manner described previously and the experimental procedure and design was the same as in Study 1, with the exception that 50 seeds per experimental unit were used. Seeds were exposed to 0, 500, 1000, 2000 or 4000 ppm GA and germination in the light or in the dark. Petri dishes were examined after 21, 35 and 49 days to reduce exposure to light.

Results

Study 1. Analysis of variance indicated that the main effects, (light, GA, and time) accounted for a very large portion of the total sum of squares. The 3 first order and the second order interactions were also highly significant, but of a lower magnitude than the main effects. The appropriate prediction equations accounted for 99% of the sums of squares for time and the 3 interactions involving time. (Fig. 1).

Major differences in rate of germination and final germination occurred between the light and dark treatments at 0, 50, 100, and 500 ppm GA; 1000 ppm GA overcame the reduced final germination but not the delay in germination. In the light, increasing GA concentrations up to 1000 ppm resulted in earlier germination. The dark treatments showed even greater responses to increasing levels of GA. The dark control and 50 ppm GA treatments showed an increasing rate of germination with time.

Since the dark treatments were exposed to short periods of light every 2 days during examination, a second study was initiated to better evaluate germination in the dark. Germination increased with increasing concentrations of GA up to 1000 ppm; concentrations above 1000 ppm were, therefore, also included in our second study.

Table 1. Predicted percentage of plant cells containing from 0 to 3 plants each based on 3 seeds per cell and germination from 30 to 80%.

No. of plants per cell	Germination (%)					
	30	40	50	60	70	80
3	3	6	12.5	22	34	51
2	19	29	37.5	43	44	38
1	44	43	37.5	29	19	10
0	34	22	12.5	6	3	1

Study 2. The percentage data from the second experiment were transformed to angles for analysis. The analysis of variance indicated that the main effects accounted for over 80% of the total sums of squares. The light × GA and the GA × time interactions were significant while light × time and the second order interaction were not. Curves drawn from the prediction equations are presented in Fig. 2. In this study there was no discernible response by the dark treatments to the brief light exposure encountered while counting radical emergence at 21 and 35 days. Germination was inhibited by maintaining the seeds in the dark. Increasing GA to 1000 and 2000 ppm produced a similar pattern of germination to that in the light, but delayed in time, and with lower final germination. At 4000 ppm GA germination was complete in 28 days and nearly so at 21 days with no difference in final germination between the light and dark treatments. The prediction equations indicate

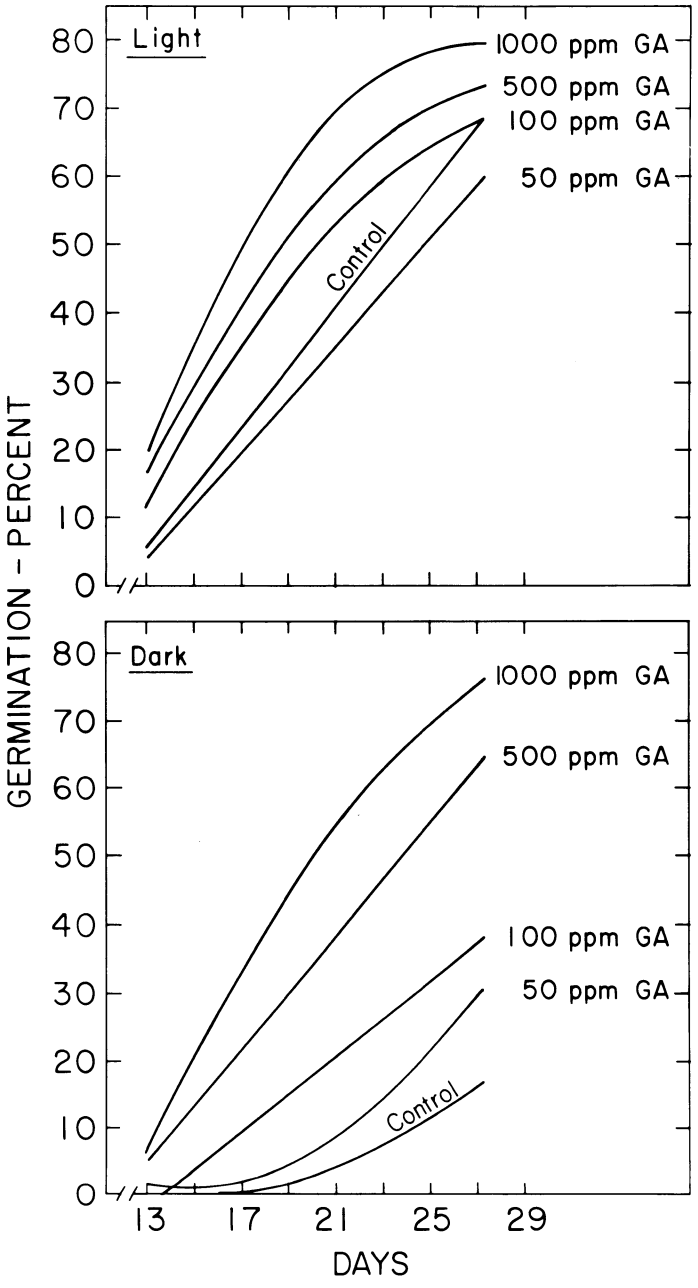

Fig. 1. Response of blueberry seed germination in light and dark at different GA concentrations, Study 1.

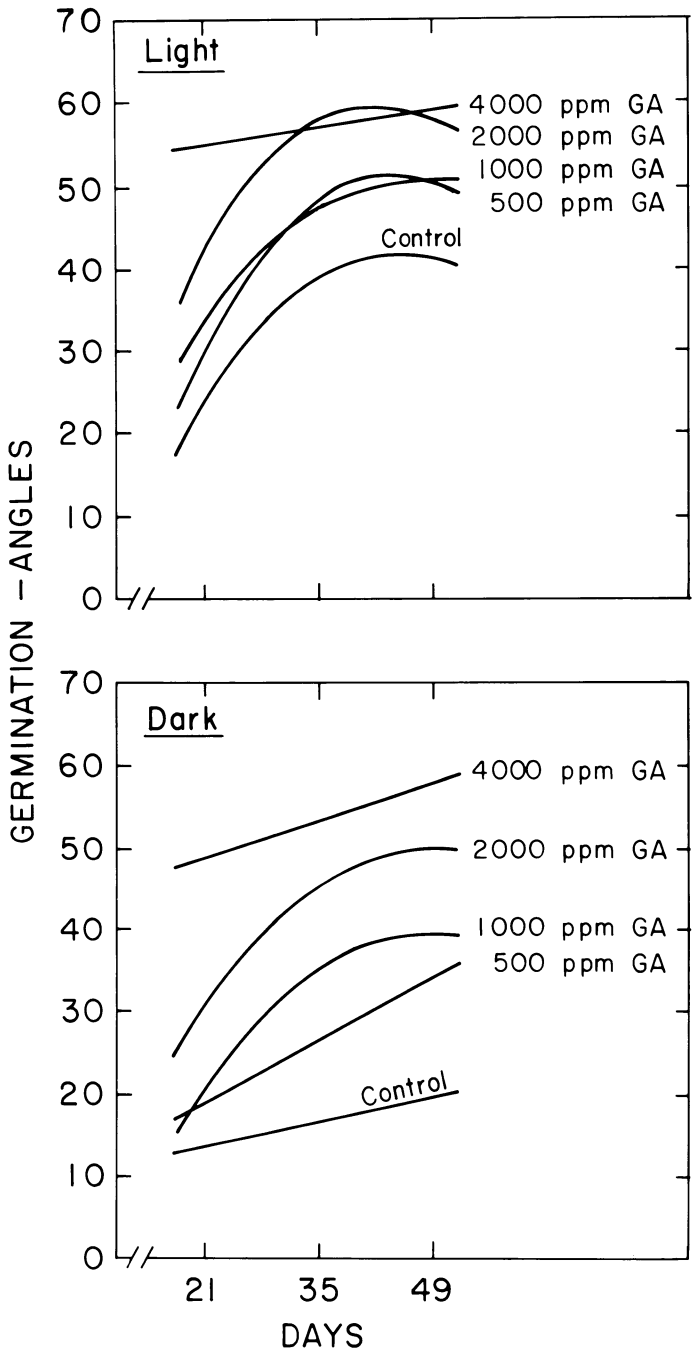

Fig. 2. Response of blueberry seed germination in light and dark at different GA concentrations, Study 2.

that increasing the concentration of GA increases the rate of germination, and that the 1000 ppm GA in the dark treatment is equivalent to the light control.

Discussion

Results from both Study 1 and 2 indicate that light is stimulatory to lowbush blueberry seed germination. This is consistent with highbush and rabbiteye blueberry seed germination. Data from Study 1 suggest that only short exposures to light every 2 days are necessary for germination of lowbush blueberry seed. Exposure of seeds in the dark to GA concentrations of 1000 ppm or above resulted in germination equivalent to that in the light. GA treatments stimulated early germination in the light as well as in the dark. Although germination increased with increasing concentrations up to 4000 ppm, concentrations above 1000 ppm GA in the light or in the dark produced abnormally curled and twisted seedlings with necrotic root tips. This was probably due to exposing the developing seedlings to these high concentrations of GA for 3 to 4 weeks. By the third week, 90% of the seeds exposed to light and 4000 ppm GA that were going to germinate had emerging radicles and thus, these seedlings were exposed to 4000 ppm GA for 4 weeks. However, it is apparent that continuous exposure to gibberellin treatments is not necessary to stimulate early germination in other *Vaccinium* species (4, 5).

If lowbush blueberry growers are to use mechanical seeding devices with multiple cell containers, then it will be necessary either to obtain predictably high and reliable germination, or to use multiple seeds per cell. In the latter case, some to many cells will contain more than 1 plant. Table 1 presents the predicted distribution of seedlings based on 3 seeds per cell and several representative germination percentages similar to those obtained in our 2 studies. These data illustrate the extreme problems of multiple plants and empty cells that are encountered when trying to grow hundreds of thousand of seedlings with unpredictable seed germination. Treatment of lowbush blueberry seeds with GA could be a practicle method of stimulating early germination and producing more uniform seedlings.

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