Removal of the D3 A3 seed grade increased average yield of the remaining grades .5 MT/ha. Return from discarding the D3 A3 grade (12% of total wt) would be \$1630/ha. Diam-air column seed grading would be a more effective method of increasing snap bean yield and return than length-air column grading.

Of the physical characteristics studied, seed wt exerted the greatest influence on snap bean pod yield. Seed length had the least influence on pod yield. Grading seed in a vertical air column was more effective than diam or length grading in separating high and low yielding seed. Length grading was the least effective method of seed grading. A combination of diam grading and air column aspiration produced a greater yield variation between grades than length-air column grading. The data indicate that diam-air column grading separate the low wt, low density seed which had a low yield potential. The energy requirement would be lower and control of air properties would be less critical for diam-air column grading than for air column alone since only the slender seed would require aspiration. Discarding or development of other uses for low yielding seed (12% of total wt) of the diam-air column grading procedure increased both yield and return from snap bean.

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Horizontal Plant Orientation Delays Flowering in *Phaseolus vulgaris* L.[1]

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Additional index words. bean, geotropism

Flowering in many plants can be geotropically influenced. Apple limbs are tied down as a commercial practice to increase flowering, and pineapple plants tipped on their sides flowered earlier than those grown upright (5). Flowering at the lower nodes of soybean plants was improved after weights were used to make stem tips grow downward (1). In apple (2) and pineapple (3) there is evidence that the geotropic stimulation may be mediated through ethylene. The effect of horizontal placement of plants on flowering of *Phaseolus vulgaris* was investigated, since ethephon treatments have increased flowering in that plant (4).

The experiment was conducted at Vicosa, Minas Gerais, Brazil, in a greenhouse averaging 20°C (night) and 27° (day). A vigorous, climbing, black bean, accession 1379, from the Germplasm Banks at Vicosa, was used. Five seeds were planted per 30 cm pot, and plants were thinned 1 week after germination to a single uniform seedling per pot. Three plants were placed in a horizontal position 15, 18, 22, 28, 31, 35, 38 and 44 days after germination. Prostrate plants were rotated 180° in the horizontal plant 4x between 6 AM and 6 PM. The no. of newly opened flowers on each plant was counted each morning, and seed no. and lateral shoots were determined at maturity.

Horizontal orientation on day 15 but not thereafter delayed the appearance of the first flower 1 week (Table 1). On day 15 the first trifoliolate leaf was just expanding. The delay in flowering by horizontal placement on day 15 but not on day 18, suggests that flower initiation occurred sometime between days 15 and 18.

Horizontal placement decreased flower no. in proportion to the date of treatment (Fig. 1). The earlier the horizontal placement the greater the decrease in flowers. Seed production was decreased by horizontal placement on days 15 and 18 only. After day 22, when 45 seeds were produced, there was no change in seed production indicating that the potted plants could only support about 45 seeds. Lateral bud break was also affected, with earlier horizontal placement resulting in proportionately more lateral shoots (Fig.1). All plants ceased flowering at the same time and senesced uniformly.

Table 1. Effect of time of horizontal placement on time of appearance of first and last flowers.

Time of horizontal placement (days after germination)	Days from germination to: First flower	Last flower
15	39a[z]	48a
18	32b	48a
22	33b	46a
28	33b	48a
33	34b	47a
Vertical controls	33b	48a

[z]Mean separation in columns by Duncan's multiple range test, 5% level.

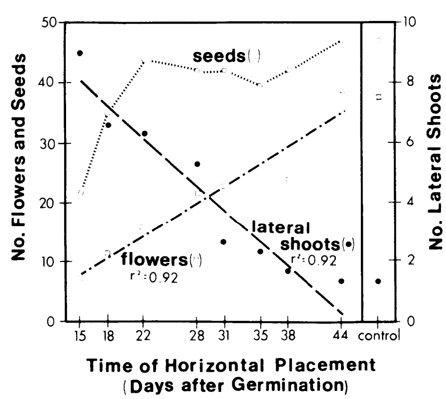

Fig. 1. No. of flowers, seeds and lateral shoots as a function of time of horizontal placement between days 15 and 44. Corresponding data for vertical control plants are shown to the right of the graph.

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Horizontal placement resulted in a syndrome of effects which included delayed flower initiation, reduced production of flowers and seeds and increased lateral branching. Inhibition of flowering by horizontal orientation seems contrary to other reports of geotropic stimulation of flowering. Fisher (1) increased soybean flowering by removing the 1 or 2 lateral shoots that developed after shoot tips were weighted downward. His conclusion, that auxin produced by shoot tips and young leaves was inhibitory to flowering, would have predicted the inverse relationship between no. of flowers and lateral branches found in this study.

My results suggest that a geotropically-induced affect on flowering can be used as a simple method for pinpointing the initiation of the reproductive period.

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Influence of N-P-K Fertilizers on Low Temperature Tolerance of Cabbage Seedlings[1]

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Abstract. **Water-soluble fertilizers applied as starter solutions were evaluated for their influence on tolerance of non-hardened cabbage (*Brassica oleracea* L. Capitata Group) to freezing temperatures. Container-grown and bare-root seedlings were treated and the effects on low temperature tolerance 3 and 9 days after application were determined. Leaves were frozen using the excised leaf test and evaluated for injury by measuring conductance of the leachate. Potasium increased the tolerance to frost in both container-grown and bare-root plants; N decreased tolerance when N and K were applied, plants were less frost tolerant than those treated with no fertilizer. Greater freezing resistance resulted when starter solutions were applied 9 days before the leaves were exposed to freezing temperatures. Distinct differences in color between freeze-killed leaves and non-injured leaves occurred when they were pressed and dried. Leaves remained green after exposure to temperatures which caused at least 50% leaching, but yellowed when leaching did not exceed 50%.**

In regions of the northern U.S. and Canada spring and fall frosts limit crop production to a few months of the year. Early vegetable crop production requires field setting of transplants which run the risk of late spring frost damage. Water containing dissolved fertilizer (i.e. starter solution) applied to plants at transplanting is generally found beneficial. However, no research has been conducted to determine if starter solutions affect the frost tolerance of tender (unhardened) seedlings. Although potash (8) and salt solutions (3) have been reported to harden plants, other reports disagree as to the role N and P play in frost tolerance (2, 4, 5).

Using Knop's formula (6), 4 test formulations (Table 1) approximated the analysis of 10–55–10, (10N–23.6K–8.3P), a commercially available starter fertilizer. A medium composed of 1 non-composted loam soil:1 sand:1 peat was used for both container-grown and bare-root plants. For container-grown plants, 1 week old 'Jet Pak' cabbage seedlings were transplanted into individual 10 cm plastic pots. After 4 weeks each pot was treated with 60 ml of the test starter solutions. The roots of these plants were not disturbed to simulate the commercial practice of transplanting peatpot-grown seedlings directly into the field. For bare-root plants, 1 week old seedlings were transplanted into wooden flats. When 4 weeks old, the plants were uprooted, shaken free of soil, transplanted individually into 10 cm plastic pots and treated with 60 ml of one test starter solution to simulate transplanting of bare-root plants in the field. During the 4 week period, plants were grown in the greenhouse under a 14 hr light regime (daylight was extended with 6.5 klx fluorescent light) at 20°C day and 15° night temp. This experiment was designed as a randomized complete block factorial with 4 single-plant replications. The 3rd true leaf was excised from each plant and subjected to one of 4 test temp.

Freezing tests were conducted 3 and 9 days after starter solution application and leaf tissue was analyzed via emission spectroscopy to determine foliar concn of NPK. Each leaf that was excised (without its petiole) was used to determine freezing tolerance as outlined by Sukumarin and Weiser (9). Freezing injury was evaluated using the electrolyte leaching technique as described by Dexter (1). In this procedure the tubes were unstoppered following removal from the freezing bath, covered with damp cheese cloth and left overnight in a 0°C refrigerator. Leaves were removed from the test tubes and each leaf was placed in a 250 ml Erlenmeyer flask containing 30 ml deionized water, stoppered and shaken at room temp for 1 hr. The conductivity of the leachate was measured with a conductivity bridge (Industrial Instruments, model no. PM-70CB). Flasks containing the leaves were autoclaved for 15 min at 132° to kill the tissue, cooled at room temp for 30 min, shaken for 1 hr and the final conductance measured. Percent leaching was calculated as follows:

$$\%\text{ leaching} = \frac{\text{conductivity after freezing}}{\text{conductivity after autoclaving} \times 100}$$

Leaves from 1 replication of each treatment were pressed. The leaves were pressed between sheets of white paper for 3 weeks, then photographed.

Starter solution lacking N but containing P and K significantly increased the freezing resistance of cabbage transplants (Table 2). Starter solutions containing N made cabbage leaves more susceptible to freezing injury. Those that contained N but lacked K further increased this susceptibility. Plants given complete starter solution (NPK) or

Table 1. Analysis of test starter solutions.

Element	N (ppm)	P (ppm)	K (ppm)
NPK	600	1400	1700
PK	–	1400	1700
NP	600	1400	–
O	–	–	–

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