Table 5. The influence of cultural method on plant and leaf fresh weight (g), leaf size (cm), and number of female flowers per plant of 'Dasher II' cucumber.

Measurements	Cultural method: Staked	Cultural method: Unstaked	LSD, 5%
Plant weight before first harvest	278	184	90
Plant weight after last harvest	530	448	79
Weight of leaves	91	71	18
Leaf length	12	10	1
Leaf width	14	13	1
No. female flowers	13	12	2

fruits per unit area when the plants were trained vertically and spaced 15 cm apart (Table 4) than when unstaked.

Results of this study indicate that substantial yield increases were obtained by vertical training of the cucumber plants. The increased yield could be attributed to the reduction of fruit rot and, more importantly, to the increase in fruit set and development of the vertically trained plants.

Theoretically, in a gynoecious cucumber each female flower should develop into a fruit of marketable size. Results of this study indicate that more female flowers set and developed into marketable fruits on vertically trained plants than on unstaked plants. Also, the fresh weight of vertically trained plants was always greater and the size of the leaves was larger than those of the unstaked plants. These results indicate that the upward training of plants increased net photosynthesis, increasing assimilates that supported an increased number of fruits. More female flowers aborted and did not develop into fruits in the unstaked treatments relative to staked, possibly because of the need for more assimilates by the unstaked plants.

The reduction in fruit rot in staked plants was achieved by improved air penetration, which reduced humidity, lessened the chances of fungal survival, and allowed for effective fungicide penetration.

The spacing generally recommended for fresh market cucumber is 30 to 45 cm between plants within the row. It was possible with vertical training of plants to reduce spacing between plants in rows to 15 cm and to increase yield significantly per unit area of land.

The cucumber plant is not heavy with fruits at any given time during harvest. The developing fruit from the first fertilized flower has an inhibitory effect on the growth of subsequently pollinated fruits (9) and has to be harvested as soon as it reaches an acceptable size to allow new fruits to develop. The light weight of the plant makes it possible to use a hand-operated stapler and a tape to tie hundreds of cucumber plants in a short time. Also, the tendrils formed by the cucumber vine help to support the plants after two or three tyings. These factors make it feasible for cucumber growers to adopt this cultural technique to improve cucumber productivity.

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HORTSCIENCE 22(1):34–36. 1987.

Effects of Nitrogen Fertilization on Production of Mechanically Harvested Snap Beans

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Additional index words. *Phaseolus vulgaris*, legume, pod quality, plant lodging

Abstract. **Nine snap bean (*Phaseolus vulgaris* L.) cultivars were evaluated at N fertilization rates of 17 and 67 kg·ha^{-1} during 1984 and 1985. Plant lodging was more severe at the high-N rate than at the low rate in both years, and pod decay was more severe at the high-N rate in 1984. 'Bush Blue Lake 47' was the only cultivar among those tested that did not have more lodging at the high-N rate than at the low-N rate. 'Flo' was the only cultivar with higher yields at the high-N rate. The cultivars evaluated showed the most favorable yield and growth responses at the N rate of 17 kg·ha^{-1}, which is lower than rates usually recommended for snap beans.**

Maximum yields of snap beans usually occur with N at 17 to 56 kg·ha^{-1} (1, 3–6). Responses to higher N rates have occurred only on very fine sandy soils (2, 4, 6). High N rates usually increase plant size but depress pod quality and mechanical harvester efficiency. Efficient harvest is characterized by a low percentage of pods left in the field (5% or less), low levels of trash in the harvested pods (5% or less), little pod breakage (<10%), and few clusters within the harvested pods. The results of several experiments in Pennsylvania showed that Bush Blue Lake-type snap beans produce maximum yields with N at 28 kg·ha^{-1} (5). Plant size, lodging, and difficulty of harvesting mechanically increased at higher N levels under a wide range of field conditions.

The objective of this study was to evaluate the effects of N rates on plant characteristics, productivity, and pod quality of nine snap bean cultivars harvested mechanically.

The experiments were conducted in 1984 and 1985 at the Plateau Experiment Station near Crossville, Tenn. Snap bean seeds were planted on 21 June 1984 on a Lily sandy loam. Soil test results indicated pH 5.9, P at 50 kg·ha^{-1}, and K at 200 kg·ha^{-1}. The site had been planted in soybeans and a winter wheat cover crop in the previous year. Prior to planting, *S*-ethyl dipropyl carbamothioate (EPTC) at 3.4 kg·ha^{-1} was broadcast and incorporated into the soil. The 1985 planting was on 17 June on a Lily sandy loam with soil test levels of pH 5.9, P at 20 kg·ha^{-1}, and K at 150 kg·ha^{-1}. After planting in 1985, 2-chloro- *N* -(2-ethyl-6-methylphenyl)- *N*-(2-methoxy-1-methylethyl)acetamide (meto-

Received for publication 6 Jan. 1986. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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Table 1. Effect of N level on snap bean plant stand, plant lodging, and crop yields.

N rate ($kg\cdot ha^{-1}$)	Plant stand (plants/m)			Plant lodging (% of total plants)			Crop yield ($kg\cdot ha^{-1}$)		
	1984	1985	Mean	1984	1985	Mean	1984	1985	Mean
17	25	19	22	26	38	32	8290	8960	8620
67	25	20	22	42	52	47	8510	9180	8850
Mean	25	20	22	34	45	40	8400	9070	8730
Significance[z]									
N rate		NS			**			NS	
Year		NS			**			NS	
N rate × year		NS			**			NS	

[z]Nonsignificant or significant at 5% (*) or 1% (**) level by F test.

Table 2. Effect of N level on snap bean pod clustering, trash, and rotten pods during harvest.

N rate ($kg\cdot ha^{-1}$)	Clustering (no. clusters/kg)			Trash (% of total harvest)			Decayed pods (% of total pods)		
	1984	1985	Mean	1984	1985	Mean	1984	1985	Mean
17	11.9	7.5	10.0	3.7	2.4	3.0	4.8	3.2	4.0
67	13.4	8.4	11.0	4.5	2.4	3.4	6.9	3.8	5.4
Mean	12.6	8.0	10.5	4.1	2.4	3.2	5.8	3.5	4.7
Significance[z]									
N rate		NS			NS			NS	
Year		**			**			**	
N rate × year		NS			NS			*	

[z]Nonsignificant or significant at 5% (*) or 1% (**) level by F test.

lachlor) was applied to the soil surface. The nine cultivars were combined factorially with banded N rates of 17 and 67 $kg\cdot ha^{-1}$. Snap bean cultivars tested were 'Bush Blue Lake 92', 'Bush Blue Lake 47', 'Labrador', 'Sprite', 'Strike', 'Atlantic', 'Peak', 'Flo', and 'Eagle'. Selected cultivars were equally divided among Bush Blue Lake, fresh market, and regular processing types. Fertilizer rates of P at 90 $kg\cdot ha^{-1}$ and K at 34 $kg\cdot ha^{-1}$ were banded with each N rate. The seedling objective was to obtain a stand of 20 to 26 plants/m of row in 1-m spacing of rows. The treatments were replicated four times and arranged in a split-plot design with N rate as the main plot and cultivar as the subplot. The experimental plots consisted of two rows 6 m long.

Plots were mechanically harvested using a two-row commercial snap bean harvester. Maturity was determined by measuring pod sizes in the field with a sieve-size gauge prior to harvesting. Pods were considered equal to commercial maturity standards when 10% to 20% of the pods for Bush Blue Lake-type cultivars passed through a no. 5 sieve with openings measuring 9.5 to 10.7 mm in diameter and when more than 80% of the pods measuring 8.4 to 9.4 mm in diameter passed through no. 4 sieve for all other cultivars. Plant stand counts and lodging ratings were made prior to harvest. A 1-kg sample of harvested pods from each experimental plot was used to determine pod clustering counts and percentage of trash, broken pods, and pods with decayed ends. Pods were labeled as clusters when one or more pods were attached to a stem >25 mm in length. Trash consisted of soil, plant leaves, and plant stems. Pods were considered as broken when any portion except the stem or pod tip was missing. Decayed pods were due to a hard rot of pot ends that touched the soil; they are usually associated with the root rot complex of *Rhizoctonia* species. A 25-pod sample was used to determine length of no. 4 sieve pods. The weight percentage of seeds in a 100-g sample of no. 4 sieve pods was determined by cutting the pods in half and removing and weighing the seed content.

Plant populations were not affected by N rate (Table 1), and plant stands were higher in 1984 than in 1985. Reasons for this difference in stand were not determined. At the high N rate, plants grew larger and lodged more severely (Table 1). Lodging was more severe in 1985 than in 1984, probably due to heavy rainfall just prior to harvesting in 1985. Significant N rate × cultivar and N rate × year interactions on plant lodging were found for the 2-year mean. 'Bush Blue Lake 47' responded differently from other cultivars tested. Lodging of 'Bush Blue Lake 47' increased only from 24% at the low N rate to 28% at the high N rate over both years. Lodging of Bush Blue Lake-type cultivars generally increased at high N rates in previous trials (5), and 'Bush Blue Lake 92' and 'Labrador' followed this trend in this trial with increases from 46% to 72% and 10% to 32%, respectively. However, 'Bush Blue Lake 47' showed different characteristics and was grown successfully in this test without excessive lodging at the high N rate. 'Labrador' had less lodging than all cultivars except 'Bush Blue Lake 47' over both years and N levels (see Table 3). Each snap bean cultivar needs evaluation at various N levels, since genetic characteristics and N fertilizer rates influence plant lodging characteristics.

Yields were not affected by N rates (Table 1). These results agree with trials with older Bush Blue Lake cultivars (5) but are contrary to trials with other cultivars (1, 3, 4, 6). The

Table 3. Effect of cultivar on snap bean plant stand, plant lodging, crop yields, pod clustering, trash, decayed pods, mean of N rates, and years.

	Crop characteristic					
Cultivar	Stand (plants/m)	Lodging (% total stand)	Yield ($kg\cdot ha^{-1}$)	Clustering (no. clusters/kg)	Trash (% of total)	Decayed pods (% of total pods)
Bush Blue Lake type						
Bush Blue Lake 92	22 bc[z]	56 f	8,500	12.1 ab	3.7 b	3.4 de
Bush Blue Lake 47	28 a	28 ab	9,900	8.4 c	2.3 c	2.3 e
Labrador	29 a	24 a	10,500	8.4 c	2.2 c	3.0 de
Fresh market type						
Strike	23 b	40 d	7,600	10.1 bc	5.0 a	7.8 a
Sprite	27 a	38 d	6,300	12.3 ab	4.0 ab	5.1 bcd
Atlantic	18 d	34 cd	8,500	9.9 bc	3.3 bc	7.3 ab
Regular processing type						
Peak	22 bc	48 e	8,700	14.3 a	3.0 bc	5.9 bc
Flo	20 bc	46 e	7,600	9.3 bc	3.0 bc	2.3 e
Eagle	21 bc	32 bc	9,900	10.1 bc	3.0 bc	3.7 cde

[z]Mean separation within columns by Duncan's multiple range test, P = 5%.

N rate cultivar interaction was significant for yield in 1984 (Table 1). 'Flo' was the only cultivar showing a yield gain at the high N rate in 1984 with an increase from 7300 to 9300 $kg \cdot ha^{-1}$. The year × cultivar interaction was also significant and was expected since cultivars differ in their response to climatic conditions. The lack of yield response at the high N rate is a characteristic of Bush Blue Lake type cultivars (5).

Pod clustering and percentage of trash during harvest were not affected by N rate (Table 2). Pod clustering and percentage of trash were more severe in 1984 than in 1985. These factors were probably related to the availability of moisture during the harvest period in 1984.

More pods with decayed ends, primarily from touching the soil, were found at the high-N rate in 1984. This decay was a result of the increased lodging at the high-N rate and the wet soil and high humidity conditions during harvest in 1984. N rate × year and year × cultivar interactions were significant, illustrating the effect of rainfall and humidity on pod decay.

Cultivar significantly influenced every factor evaluated (Table 3). Highest plant stands involved 'Bush Blue Lake 47', 'Labrador', and 'Sprite', with 'Labrador' being the most productive cultivar in the trial and having less lodging than all cultivars except 'Bush Blue Lake 47'. Pod clustering was more severe with 'Peak' than with all other cultivars, except 'Sprite' and 'Bush Blue Lake 92'. More trash was harvested with 'Strike' than with any cultivar except 'Sprite'. 'Strike' had 7.8% decayed pods, which was higher than with any cultivar except 'Atlantic', with 7.3% decayed pods. The percentage of pod decay of these two cultivars was higher than the accepted standard levels.

The percentage of broken pods, pod length, and percentage of seed in pods averaged 13%, 15 cm, and 6.6%, respectively, and did not vary with N rate or year.

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HortScience 22(1):36–38. 1987.

Influence of HPS Supplementary Lighting on Growth and Yield of Greenhouse Cucumbers

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Additional index words. *Cucumis sativus*, sequence cropping, annual production, supplemental light, high-pressure sodium lamps

Abstract. **Four cultivars of greenhouse cucumber (*Cucumis sativus* L. 'Corona', 'Farbiola', 'Pandex', and 'Sandra') were grown under four lighting conditions: natural light and natural light supplemented by 100, 200, or 300 $\mu mol \cdot s^{-1} \cdot m^{-2}$ provided by high-pressure sodium lamps for a photoperiod of 18 hr. For this purpose, transplants were first seeded on 24 Sept. 1984, transplanted on 23 Oct., and grown according to the successive cropping method. Supplemental lighting enhanced plant growth and increased yield. Our data indicate that a marketable yield of 240 fruit/m² per year of greenhouse cucumbers could be obtained with supplementary lighting of 300 $\mu mol \cdot s^{-1} \cdot m^{-2}$.**

Cucumber plants require high levels of light in order to grow rapidly and produce heavily. In autumn and winter in northern latitudes, vegetative growth is retarded and the majority of young fruits abort. Low yields obtained under these conditions, in addition to high heating costs, do not allow profitable cropping. Consequently, greenhouse cucumber culture in northern areas is confined to spring and summer when light levels are high. Artificial lighting during the periods of low light intensity would lengthen the production season and permit year-round production.

Several research studies showed the benefits of supplementary lighting. Boivin et al. (5) reported that young tomato plants transplanted on 6 Feb. in Québec and grown under supplementary light of 50, 100, and 150 $\mu mol \cdot s^{-1} \cdot m^{-2}$ of photosynthetically active radiation (PAR) (400–700 nm) during the nursery period provided an increase in early yields (3 first weeks) of 19%, 31%, and 42%, respectively, in comparison with transplants grown under natural light only. Supplementary lighting allowed a significant increase in yields for a winter tomato greenhouse production (3, 8). Bacher and Hallig (2) observed that light supplied during the nursery period enabled production of vigorous cucumber transplants with dark green color and early production without increasing the total yield. Fluorescent lighting supplied during the production period tripled and even quadrupled November and December cucumber yields compared to those of control plants (7). Blom and Ingratta (4) exposed cucumber plants to an irradiance of 5.3 $W \cdot m^{-2}$ supplied by high-pressure sodium (HPS) lamps, and obtained an increase in yields of 7.8% and 6% for the spring and fall crop, respectively. These yield increases under their conditions were, however, insufficient to show the profitability of artificial lighting.

Hydro-generated electricity, an abundant renewable source of energy in Québec, is available to greenhouse growers at a very low price. In order to benefit from this energy, researchers advocate the use of the high irradiance that can be provided by supplementary lighting for the production of greenhouse vegetables (3). According to Klering (9), every 1% reduction in light penetration in a greenhouse leads to a 1% yield reduction. Therefore, any supplementary light energy supplied during unfavorable light conditions should increase yields. We studied the influence of four irradiance levels on the vegetative growth and yield of four greenhouse cucumber cultivars grown under Québec climatic conditions.

The experiment was conducted in a 55-m² glasshouse compartment. Four cultivars—'Corona', 'Sandra', 'Farbiola', and 'Pandex'—were submitted to four levels of irradiance: natural light and natural light supplemented by 100, 200, 300 $\mu mol \cdot s^{-1} \cdot m^{-2}$ measured at 0.75 m below the lamps by a radiometer Li-185 from Lambda Instruments. Irradiance at bag height was 22, 51, and 98.5 $\mu mol \cdot s^{-1} \cdot m^{-2}$, respectively. HPS lamps (400 or 1000 W) extended the photoperiod to 18 hr. The lights were turned on from 0430 to 0830 HR and from 30 min before sunset to 2230 HR. Lights were also on during cloudy days.

A split-plot design was used with two replications of the four lighting treatments as main plots and the four cultivars as subplots. An analysis of variance and a regression analysis were performed for all data. Each lighting treatment covered an area of 6 m²,

Received for publication 5 Nov. 1985. We acknowledge Agriculture Canada and the Quebec Agricultural Research Council for their financial support and René Pouliot for his technical assistance. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.