which of these hypotheses is correct. If this extreme response was genetic, we should be able to fix these effects through selection.

The conclusions based on this covariance analysis are that yield advantages conferred by colored seed are largely effective at the early stages of growth and are probably related to superior emergence and seedling vigor. These yield advantages, however, are real and significant, and our studies suggest that selection for increased yield will be more successful in colored-seeded snap bean lines than in white-seeded lines. Furthermore, we have found it relatively easy to develop colored-seeded lines with resistance to diseases caused by *Rhizoctonia solani,* and there were also indications that resistance to 2 other root-rot diseases was also associated with colored seed.

This study, using a wide range of genetic material grown during 2 seasons and using comparisons made within similar genetic backgrounds, revealed a consistent advantage for lines with colored seed, even without specific genes for resistance to *Rhizoctonia* diseases. This confirms the statement by Hoffman (2) that although yields increased about 15% over the 22-year period of the Southern Cooperative Snap Bean Trials, yields could have been increased an additional 25% through the use of colored-seeded cultivars. This figure probably represents a lower limit because much more emphasis has been placed on the selection of white-seeded rather than colored-seeded lines. Our results suggest that a more realistic figure may be nearer 50%.

The demand for white-seeded snap beans for processing is based on current quality standards requiring a clear liquor. A discussion of quality standards is beyond the scope of this report, but our data suggest that by maintaining this criterion for quality (i.e., clear liquor) we are imposing a loss to growers that must ultimately be reflected in higher cost to the consumer. We maintain that current standards should be re-examined to determine whether they reflect true quality or are based on unimportant criteria. If clear liquor is a valid indicator of quality, it should remain as part of the standards, but it may be merely a cosmetic factor based on individual eye appeal and unrelated to overall consumer acceptance. If this latter is the case, it is both unwise and unreasonable to place this burden upon both breeders and growers when the evidence indicates crop yields can be greatly increased simply by changing to cultivars with colored seed.

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Studies on Lettuce Seed Quality: III. Relationships between Flowering Pattern, Seed Yield, and Seed Quality[1]

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Abstract. Lettuce plants (*Lactuca sativa* L.) showed definite flowering peaks over a 70-day period. Over 90% of the seed yield was from flowers which opened during the first 35 days, and seed produced from flowers opening during the first 2 flowering peaks were heavier than those produced later in the season. Seed size was not correlated with number of seeds per flower head. Seed yield and quality were not affected by early harvest or by withholding water and nutrients during the last half of the flowering period. Flowering rate, seed yield, and seed quality were not related to air temperature in the range 67 to 94°F.

The lettuce inflorescence consists of a cymose cluster of flower heads with the oldest head of the inflorescence terminal on the main axis (1). We have observed that lateral branches also have terminal flowers which are the first to open on their respective branches; however, other than the terminal flower, position on the inflorescence is not related to flowering time.

Jones (2) reported definite flowering peaks for individual lettuce plants, but flowers were not counted for the entire flowering period. He observed that flowering rate was influenced by fluctuations in temp. He did not evaluate yield directly, but counted the no. of mature seed heads containing seeds.

Intensive studies on lettuce seed quality during the last 3 years have indicated that any seed population (including seeds from a single plant) has a wide range of seed wt and size. Seed wt has been shown to have positive correlations with both seed vigor (4) and subsequent growth (3, 5).

We attempted to determine the relationship of time of flowering to yield and quality of seeds produced by flowers at particular times during the season. We also attempted to determine whether seed wt was influenced by no. of seeds per flower head.

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Materials and Methods

1971 Experiment. 'Calmar' seed obtained in 1970 was planted in a greenhouse in July, 1971 in 20-liter containers filled with a soil mixture of soil:sand:sphagnum peat (2:2:3). Nutrients were supplied on alternate days by introducing nutrient solution into a drip irrigation system. The nutrient solution had the following composition expressed in ppm: 120 N, 15 P, 120 K, 100 Ca, 24 Mg, 2.5 Fe, 0.025 Zn, 32 S, 0.25 Mn, 0.25 B, 0.01 Cu, 0.005 Mo.

Each morning for 73 days (Oct. 2-Dec. 13), newly-opened flowers were labeled with colored plastic tags on 4 randomly selected plants. The plants were kept in the greenhouse for an additional 20 days to allow the last flowers to mature. Flowers on mature heads were counted on 3 plants and the seed from each day's flowers were separated, counted, and weighed. The fourth plant was used for a single flower-head study.

1972 Experiments. Seed harvested from greenhouse plants grown in 1971 were planted May 1, 1972, and flowers of 2 plants were tagged as before during the 75-day flowering period (Aug. 22-Nov. 4). Cultural practices and experimental procedures were the same as those of the previous year. Temperature of the air surrounding each tagged plant was determined during the entire flowering period. In another experiment, inflorescences from 10 plants were harvested 35-42 days after the first flower opened. In a second group of 10 plants, water and nutrient supplies were terminated 35-42 days after the appearance of the first flower but the inflorescences remained intact and were harvested at the end of the normal flowering season. Twenty control plants remained intact, continued to receive water and nutrients, and were harvested after 73 days of flowering. Seed harvested from each treatment were separated on an air column into 3 fractions varying in seed wt and tested for vigor on the slant test (4), in which root length was measured at the third day.

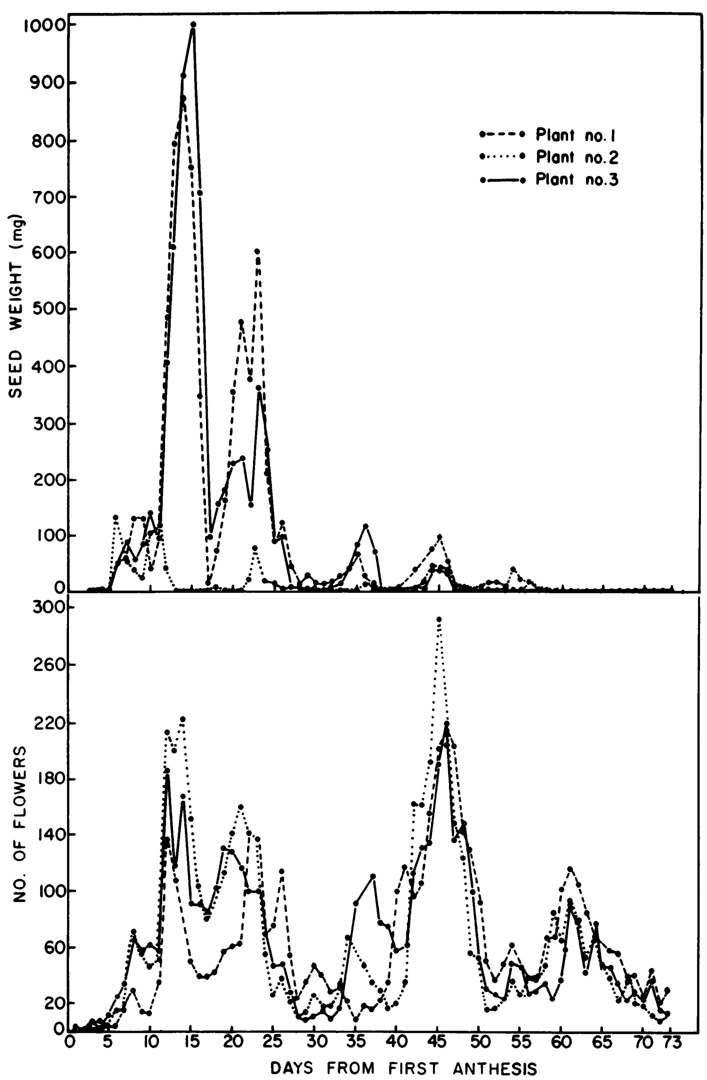

Fig. 1. Seed production (top) and flowering (bottom) data for 3 lettuce plants in 1971.

Results and Discussion

1971 Experiment. The 3 plants whose flowers were tagged and counted showed remarkably similar flowering patterns (Fig. 1). Of the 4 definite flowering peaks, 2 major peaks occurred between the second and fourth weeks of flowering. After the second peak there was a decline for about 10 days followed by the third and highest peak (up to 300 flowers per plant per day). The third peak was followed by another decline which lasted for about 10 days and a fourth and final peak occurred during the ninth week of flowering. Seed production was also determined for the 3 plants (Fig. 1). More than 90% of the total seed yield came from the first 2 flowering peaks which occurred during the first month. Plant number 2 (Fig. 1) suffered some seed loss when we separated branches of the inflorescence in order to study flowering and seed production patterns of the individual branches. The flowering curve of plant number 2, however, is very much like that of the other 2 plants, indicating that all of the flower tags were collected. Flowering patterns for 7 branches on a single inflorescence revealed a similarity between each individual branch and the whole plant. Flowering and seed production patterns of the uppermost branch are shown in Fig. 2. Seed production on the individual branch also resembled that on the whole plant, even though there was a severe loss of seed due to manipulation of branches. The same pattern existed for all 7 branches except that more flowers were produced later in the season on lower, later branches.

Number of seed and average seed wt were determined for seed set daily over the entire flowering period for each of 2 plants. The results for both were similar (Fig. 3). Early flowers, excluding the first 10-12 days, produced the most and heaviest seed.

Flowers opening 11, 18, 25, and 36 days after first anthesis were grouped according to the number of seeds per head and the average wt per seed was determined. The data (Table 1) revealed no relationship between average seed wt and number of mature seed in a single flower head. Thus, competition was not

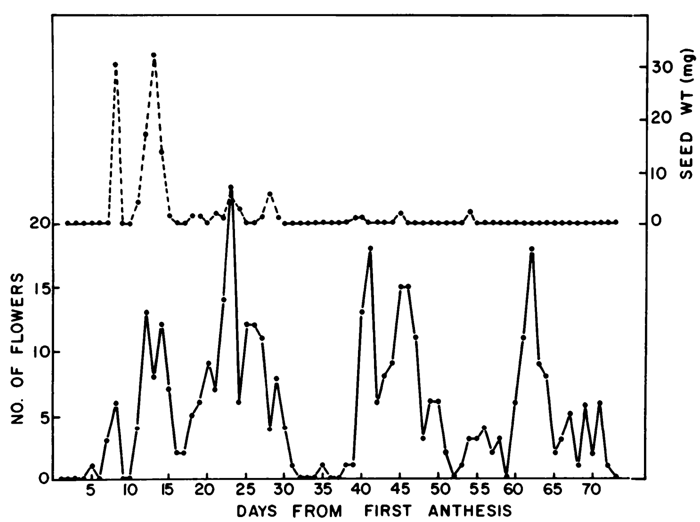

Fig. 2. Flowering and seed production on an individual branch of lettuce.

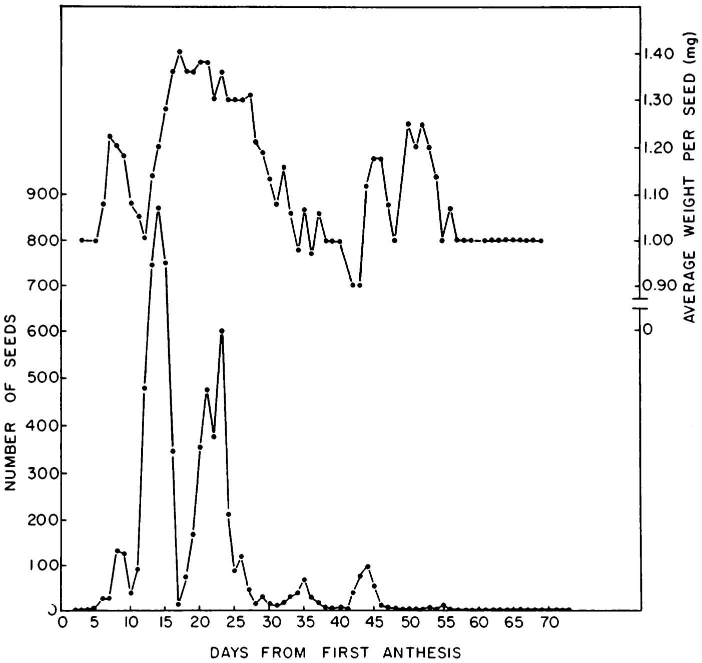

Fig. 3. Average seed wt (top) and number of seeds (bottom) collected in 1971 from flower heads of lettuce labeled daily.

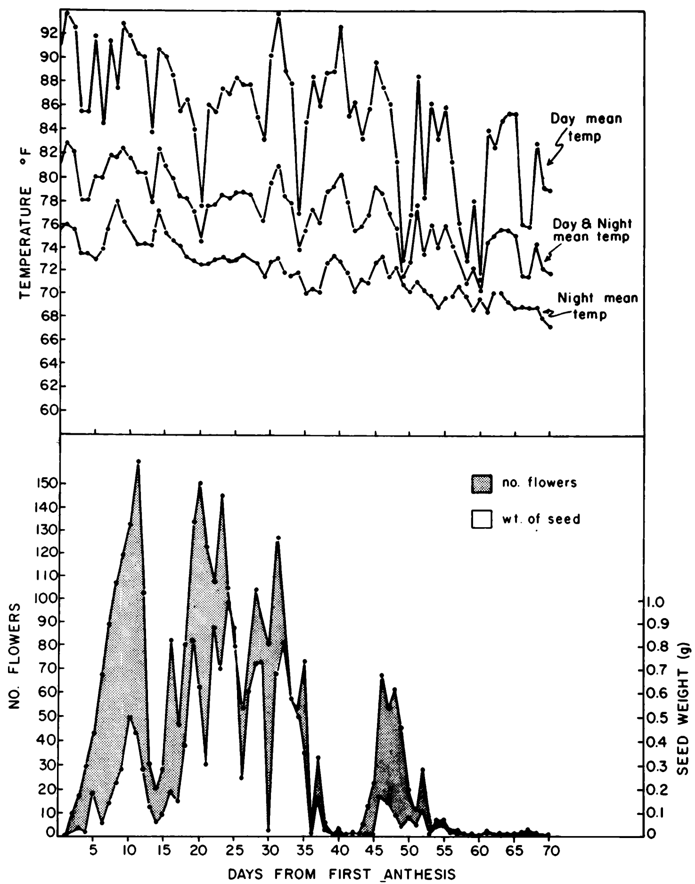

Fig. 4. Flowering and seed production data of a 1972 lettuce plant (bottom), and temp fluctuation during the flowering period (top).

apparent among seeds on the same composite flower head.

1972 Experiments. In view of the important practical implications of the 1971 results, i.e. shortening seed production period, the experiment was repeated and extended during the following season. In order to more nearly relate experimental data to field application, the planting date in these experiments was made to coincide with that for commercial lettuce seed production in California. Also, we attempted to reduce seed shattering by collecting the seed in the greenhouse rather than harvesting plants and transporting them to the laboratory for seed collection as had been done in 1971.

Table 1. Relationship between average seed wt (mg) and number of seeds per flower head of lettuce.

	No. of seeds per flower head										
Days[z]	1	2	3	4	5	6	7	8	9	10	11	Means
11	0.797	0.993	0.834	0.939	0.986	–	0.924	1.021	–	–	–	0.928
18	1.326	1.293	1.333	1.435	1.182	1.403	1.225	–	–	–	–	1.314
25	0.800	0.987	1.268	1.134	1.147	1.196	1.086	1.207	–	–	1.207	1.115
36	1.077	1.151	0.907	1.247	1.162	1.211	–	–	–	–	–	1.126
Means	1.066	1.124	1.101	1.036	1.131	1.243	1.109	1.058	–	–	1.207	

[z]Number of days after anthesis of the terminal flower of the inflorescence.

Much of the seed was produced during the first half of the flowering period but, in contrast with 1971 results, late flowering was not pronounced (Fig. 4).

An attempt was made to determine whether fluctuating air temp could account for the peaks in flowering and seed production. Air temp measurements were recorded 60 times during every 24-hr cycle (Fig. 4). The day temp curve represents average temp readings from 8:00 AM to 5:00 PM. Night temp represents the period from 5:00 PM, when temp began to drop, to 8:00 AM when temp began to rise. The middle curve represents the mean temp over the entire 24-hr cycle. No relationship was observed between flower or seed production and temp fluctuation. However, on bright mornings more flowers opened and they opened earlier. This observation suggests that light intensity might influence the flowering pattern and could explain the correlations reported by Jones (2) between flowering rate and air temp. Air temp is frequently correlated with radiation intensity when temp is not controlled.

In another experiment, we attempted to extend the results suggesting that seed is produced primarily from early flowers. This experiment compared seed production among control plants, plants harvested after 5-6 weeks of flowering, and plants which received no water or nutrient solution after 5-6 weeks of flowering. Seed yield, vigor, and size distribution were not significantly affected by either early harvest or early termination of water and nutrients (Table 2). Earlier reports from this laboratory have shown that seed quality, as determined by the slant test for vigor, is correlated with seed wt. The data in Table 2 show that seed quality, based on seed vigor and percent and wt of heavy seeds, was the same among all 3 treatments. Seed from all 3 treatments had a vigor value of more than 2.5 cm in the slant test of Smith et al. (4, 5). This value was chosen by them as the division between high and low seed vigor.

While the results reported here represent a potential

Table 2. Lettuce seed yield and vigor as affected by early harvest or early termination of water and nutrients.[z]

Treatment	Yield/plant (g)	Seed distribution[v] (% of total) Light	Medium	Heavy	Wt/seed in heavy fraction (mg)	Average vigor (cm)
Control[y]	17.9	2.8	10.0	87.2	1.121	2.62
Early harvest[x]	14.7	7.8	14.4	77.8	1.124	2.75
Nutrients and water withheld[w]	19.2	3.8	11.6	84.5	1.128	2.76

[z]Mean separation in columns by Duncan's multiple range test at 5% level not significant.

[y]Harvested 90-100 days after first flower.

[x]Harvested 35-42 days after first flower.

[w]Water and nutrients terminated 35-42 days after first flower, harvested 60 days thereafter.

[v]Seed were separated into 3 fractions on an air column.

contribution to commercial lettuce production (seed and fresh market heads), we realize that field trials must be used to confirm them.

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Interaction of Low Temperature Storage and Maturity on Quality of 'Early Italian' Prunes[1]

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Abstract. Ripening of 'Early Italian' prunes, harvested at maturity suitable for fresh shipment, was enhanced by several days exposure to low temperature (1°C). Cold treated prunes developed more color, less acidity and were softer than prunes ripened immediately at 21°. No changes in these characteristics occurred during the cold period. Canned whole fruit and juice reflected these changes and were readily detected by a taste panel.

To minimize post-harvest development of internal browning 'Early Italian' prunes (*Prunus domestica* L.) are harvested for fresh shipment while still quite firm, green and astringent (6), and a ripening period of several days is required for them to become palatable.

It has been shown recently that 'Early Italian' prunes harvested at shipping maturity soften and ripen more rapidly and more completely after exposure to low temp (4). If culls and fruit that are surplus to fresh shipment requirements are to be utilized in processed form ripening must be comparable to that of fruit ripened on the tree before processing. This report describes the effects of post-harvest ripening on quality characteristics of canned whole fruit and juice and how ripening is modified by exposure to low temp and by maturity at harvest.

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[2]Texturepress Model TP-2, Food Technology Corp, Reston, VA.

Materials and Methods

'Richards Early Italian' prune (*Prunus domestica,* L.) was used throughout this work. Because the fruit is not utilized in the dried state we will call them plums.

In 1970 an unreplicated experiment compared fruit stored at 1°C for 0, 3, 7, 10, 14 and 21 days, using fruit of early, mid-season, and late fresh market maturities and canning ripe fruit. With the Magness-Taylor pressure tester using the .79 cm head on the unpeeled cheek 3 successive harvests tested 6.8, 5.4 and 4.1 kg, respectively. The fruit was judged to be canning ripe when losses to drop and cullage began to increase rapidly.

In 1971 plums harvested at 3 stages of maturity were analyzed at harvest, after 14 days at 0°, and after ripening at 21° following 14 days' cold storage.

In 1972, 6 trees were harvested at early, mid-season, and late stages of maturity. At each maturity fruit exposed to 14 days at 1°C before ripening at 21° was compared with fruit ripened with no exposure to cold. Fruit was analyzed at harvest and after ripening. Ripened fruit was canned whole in 12 oz. cans, using 40% sucrose syrup at 85°C, steam exhausting 4 min at 90°, sealing, cooking 14 min at 99°, and water cooling 20 min.

An additional sample from each treatment was made into juice as follows: To a weighed sample of pitted fruit was added