increase of 0.06 units from lye peeling. The
addition of tablets containing citric acid-calcium
sulfate-sodium chloride reduced the pH more
than citric acid alone.

The yield of tomatoes obtained by lye peeling
was higher and the peel removal from tomatoes
was more complete than that obtained by steam
peeling. There was no significant treatment
effect on the color or the total solids of the
canned tomatoes.

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DETACHMENT CHARACTERISTICS OF SNAP BEAN
PODS AND PEDICELS

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ABSTRACT

Harvester, Provider and Astro varieties of
snap beans were evaluated during one season
for pod detachment location during mechanical
harvesting. Pods were separated from the plant
stems at four locations: in the stem, between
stem and pedicel, between pod and pedicel, and
in the pod. One-fifth of the Provider detach-
ments were in broken pods compared with one
third of the Harvester and Astro detachments.
Attached stems were found on 11 percent of the
Harvester pods and 1 percent of the Providers.

Significant correlations were found between
pod weight, pedicel diameter, and detachment
force for five varieties of snap beans harvested
at widely varying maturities. As the pods and
pedicels increased in size, detachment force also
increased.

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INTRODUCTION

Many pod and plant characteristics have been
considered in developing the varieties of snap
beans grown commercially in Florida. In the
past, emphasis has been placed on pod character-
istics such as shape, length, straightness, rough-
ness, color and uniformity. However, rapid de-
velopment of mechanical harvesting has created
new demands for information on the separation
of bean pods from their stems. Machine-harvested
beans are inferior in quality to those harvested
by hand because of broken pods and attached
stem sections. In a consumer acceptance test in
South Carolina retail stores, 63 percent of the
beans sold were hand-harvested and only 37 per-
cent were machine-harvested (3).

The location of different fruit-stem separation
points for oranges (6) and lemons (1) have
been differentiated because of their influence on
the market potential of the fruit. An abscission
layer normally develops in tomato fruit pedicels
at a joint located mid-way between fruit and
stem. When these tomatoes are mechanically
harvested, the sections of pedicels attached to the
fruit often puncture other fruit. Tomatoes with
jointless pedicels have an abscission layer be-
between fruit and pedicel, and harvesting results in a stemless fruit. During development of a tomato fruit, the pedicel diameter increases two or three times (5). Current research shows that absence of pedicels is essential on machine-harvested fruit intended for fresh market (4, 11).

Abscission and its control are often factors in the harvesting of mature fruits and vegetables. In the majority of crops senescence precedes abscission, and the fruits ripen before they fall. Abscission can be accelerated or retarded chemically and physically, but usually a healthy plant part does not detach without outside influence. Chemicals such as ethylene and cycloheximide stimulate abscission of citrus fruits and may be aids to mechanical harvesting (2, 7). Growth regulators such as indolebutyric acid increased pedicel diameter and reduced premature dropping of lima bean pods (12).

The harvesting of snap bean pods is made difficult by the lack of an abscission zone between pod and stem, and the lack of pod toughness. Pods harvested by hand usually have the pedicel attached but the pedicel does not damage other pods during marketing. In mechanical harvesting, metal fingers move through the plant and break the pods from the stems through the weakest area which may be the pod itself. Bean breeders have emphasized the importance of pod tenderness and elimination of toughness for better eating quality.

At the time of harvest, bean pods are actively growing and the seeds are mostly very immature. Once-over harvesting by machine results in a wide range of maturity and pod sizes. Ten percent of the total harvest may consist of immature pods less than 1/4 inch in diameter. Four samples of beans, each consisting of 10 pounds, were obtained at each farm and the detachment point of each pod was determined.

Pod size and detachment force measurements were made during April, 1970, for five varieties grown commercially in eastern Broward County. Harvester, Provider, Astro, Sprite and Avalanche varieties were each sampled at one farm on the day of commercial harvest. For each variety 100 pods, varying widely in size and maturity were selected at random locations in the field and detached with a pull force gauge (10). Detachment force, pod and pedicel diameters, and pod weight were measured for each pod.

**Experimental Methods**

The locations of pod detachment points were determined for three varieties of snap beans grown commercially and harvested by machines in eastern Broward County during April, 1970. Harvester, Provider and Astro varieties were each sampled at two farms after the beans had been mechanically sized to remove immature pods less than 1/4 inch in diameter. Four samples of beans, each consisting of 10 pounds, were obtained at each farm and the detachment point of each pod was determined.

When force was applied to bean pods by the harvester, the pods were detached at one of the following four locations:

- **Point 1. In stem.** When this occurs, stem sections or clusters of pods need to be removed from marketable beans.
- **Point 2. Between stem and pedicel.** Detachment point where pedicel was attached to stem, leaving entire pedicel on the pod.
- **Point 3. Between pod and pedicel.** Detachment point where pedicel was attached to pod, leaving the enlarged receptacle on the pod.
- **Point 4. In pod.** Detachment point beyond receptacle, resulting in broken pod. This break often occurs in the neck of the bean very close to the pedicel, and may not be considered broken in comparison with pods broken into halves or quarters.

In-stem detachments, point 1, were found much less frequently than detachments at the other three locations (Table 1). Stem detachments occurred most often in Harvester variety where 7 and 15 percent of the 40 pound samples had attached stems. Provider pods had practically no attached stems, indicating that the stems were stronger than other detachment
Table 1. Location of detachment points in three varieties of machine-harvested snap beans.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Sample 1/</th>
<th>Detachment Location 2/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Point 1</td>
<td>Point 2</td>
</tr>
<tr>
<td></td>
<td>In stem</td>
<td>Stem-pedicel</td>
</tr>
<tr>
<td></td>
<td>Percent of sample detached at each point 3/</td>
<td></td>
</tr>
<tr>
<td>Harvester</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>7 b</td>
<td>25 e</td>
</tr>
<tr>
<td>2</td>
<td>15 a</td>
<td>12 f</td>
</tr>
<tr>
<td>Variety mean</td>
<td>11</td>
<td>18 y</td>
</tr>
<tr>
<td>Provider</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0 d</td>
<td>77 a</td>
</tr>
<tr>
<td>4</td>
<td>1 cd</td>
<td>56 b</td>
</tr>
<tr>
<td>Variety mean</td>
<td>1</td>
<td>66 x</td>
</tr>
<tr>
<td>Astro</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4 bc</td>
<td>38 c</td>
</tr>
<tr>
<td>6</td>
<td>3 cd</td>
<td>30 d</td>
</tr>
<tr>
<td>Variety mean</td>
<td>4</td>
<td>34 xy</td>
</tr>
</tbody>
</table>

1/ Four 10-pound samples from each of six growers.

2/ Sample data (source of beans) within a column followed by different letters (a, b, c) are significantly different at the 5% level.

3/ Average of 4 replicates.

4/ Variety means within a column followed by different letters (x, y) are significantly different at the 5% level.

points. Although differences among point 1 variety means were not significant, there were significant differences among individual growers.

Sixty-six percent of the Provider pods detached at point 2, compared with much lower percentages of stem-pedicel detachment for the other two varieties. Since sources of beans all differed significantly in point 2 detachment, it is evident that production and harvesting factors, as well as genetic factors, influence detachment location.

Neither varieties nor sources of beans differed
significantly in their point 3 detachment, although Harvester averaged 34 percent compared with only 15 percent for Provider.

Broken-pod detachment, point 4, was found in more than one-third of the Harvester and Astro pods and in 18 percent of the Providers.

Different locations of detachment are distinguished because of their influence on post-harvest grading requirements and market quality. Detachment at point 1 requires hand grasping to remove attached stems and separate clusters. Detachment involving any amount of pod breakage results in subsequent discoloration and decay. Detachments at points 2 and 3 are desired for quality maintenance and reduction in grading requirements.

Six pod weight classes were established to include the minimum and maximum weights of all pods of the 5 varieties sampled (100 pods per variety), and the average detachment forces for each of the weight classes are shown in Table 2. There were no Harvester and Provider pods in the smallest class (0.5-1.9 grams) and no Sprite pods weighed over 6.9 grams. The correlations between individual pod weights and detachment forces were significant for each of the five varieties measured (Table 2). As the pod weights increased, the force necessary to detach also increased. The Sprite pods, with the lowest total weight (100 pods) among the varieties, had a correlation coefficient of .71 between pod weight and pull force. This compared with a coefficient of .47 for the Provider pods, which were the heaviest of the five varieties.

Although the five varieties of beans were harvested in the Pompano area in a 12-day period, direct comparisons of detachment force measurements among varieties were not made, because the pods of each variety were not the same maturity. Previous tests indicated that varieties differ in detachment force (10).

Pedicel diameters ranged from .04 to .085 inch among the five varieties (Table 2). Sprite, the variety with the smallest pods, also had pedicels with the smallest diameter (.04-.06), compared with a range of .055 to .085 for Harvester pedicels. The correlations between pedicel diameters and detachment forces were all statistically significant, and these coefficients were slightly higher or lower than the corresponding coefficients for pod weight and detachment force.

The relationships between pod diameter (suture to suture) and detachment force measurements for the five varieties were very similar to the pod weight vs. force measurements. Four of the correlation coefficients using pod diameter as an index of pod size were within .02 of the corresponding coefficients using pod weight (Table 2).

The highest correlation coefficients obtained in this study were between pod weight and pedicle diameter. These coefficients, ranging from .68 for Avalanche to .79 for Astro, indicated that as pods increased in weight, their pedicels also increased in diameter.

Although all of the correlations in Table 2 are statistically significant, the highest coefficient, .79, accounts for only 62 percent of the total variation among all factors affecting that relationship. When a correlation of .53 between pod weight and detachment force (Harvester variety) indicates that pod weight accounts for only 28 percent of the factors governing the force required to harvest, it is obvious that additional information is needed. These results indicate that varietal, environmental and maturity differences are important characteristics affecting location of snap bean pod detachment and detachment force.

LITERATURE CITED

Table 2. Relationship of pod and pedicel size to detachment force for five varieties of snap beans.

<table>
<thead>
<tr>
<th>Pod character</th>
<th>Variety</th>
<th>Detachment (pull) force - pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Harvest</td>
<td>Provider</td>
</tr>
<tr>
<td>Weight grams</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.5 - 1.9</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>2.0 - 3.9</td>
<td>1.8</td>
<td>0.9</td>
</tr>
<tr>
<td>4.0 - 4.9</td>
<td>3.6</td>
<td>1.6</td>
</tr>
<tr>
<td>5.0 - 5.9</td>
<td>3.6</td>
<td>1.7</td>
</tr>
<tr>
<td>6.0 - 6.9</td>
<td>4.2</td>
<td>1.8</td>
</tr>
<tr>
<td>7.0 - +</td>
<td>4.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Pedicel diameter inches</td>
<td></td>
<td></td>
</tr>
<tr>
<td>.04</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>.045</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>.05</td>
<td>- -</td>
<td>- -</td>
</tr>
<tr>
<td>.055</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>.06</td>
<td>2.0</td>
<td>1.7</td>
</tr>
<tr>
<td>.065</td>
<td>2.7</td>
<td>2.0</td>
</tr>
<tr>
<td>.07</td>
<td>3.5</td>
<td>2.5</td>
</tr>
<tr>
<td>.075</td>
<td>3.6</td>
<td>- -</td>
</tr>
<tr>
<td>.08</td>
<td>4.6</td>
<td>- -</td>
</tr>
<tr>
<td>.085</td>
<td>5.0</td>
<td>- -</td>
</tr>
</tbody>
</table>

Correlation Coefficients

| Pod weight vs. pull force | .53 | .47 | .57 | .71 | .61 |
| Pedicel diameter vs. pull force | .61 | .41 | .63 | .64 | .48 |
| Pod diameter vs. pull force | .53 | .48 | .58 | .69 | .55 |
| Pod weight vs. pedicel diameter | .76 | .74 | .79 | .78 | .68 |

1/ Average of 100 pods for each variety.

2/ All coefficients are significant at 1% level.