Beltville test, 1969. Usable yield averaged 4.69 and 2.78 tons/acre for 'Hungarian Yellow Wax Hot' and 'Keystone Resistant Giant', respectively, and was not affected by the clipping treatments (Table 1).

Beltville test, 1970. Usable yield for both cultivars was significantly larger from plants which were clipped 12 days before transplant harvest (Table 1). This increased yield was noticeable in all 4 harvests. Yields from non-clipped plants and from plants clipped 6 days before transplant harvest were very similar.

These results indicate that clipped pepper transplants will perform as well as non-clipped ones. In 2 of the 4 tests, the pepper plants clipped 12 days prior to transplant harvest out-yielded the non-clipped ones. In most instances, the performance of those plants clipped 12 days was superior to those clipped 6 days prior to transplant harvest. Yield for the early harvest was not reduced by transplant clipping.

A clipped pepper transplant would be much smaller than a non-clipped plant of the same age. This should result in reduced packaging and transportation costs because more transplants can be packed per crate.

Regulations for the production of Georgia certified pepper plants specify that plants must be free of infectious diseases (1). The clipping technique can cause major disease problems by dissemination of certain plant pathogens as recently shown by McCarter and Jaworski (4, 5) with tomatoes. Since many tomato diseases are also found on peppers, there is a potential danger of spreading pepper pathogens from diseased to healthy pepper transplants by the clipping practice. Therefore, the clipping practice should only be used in pepper transplant fields that are free from potentially serious pathogens.

Effects of Plant Population, Nitrogen, and Harvest Date on Yield and Maturity of Single-Harvested Broccoli

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Abstract. The effects of various equidistant plant spacings, rate of N and harvest date on the yield and maturity of single-harvested broccoli (Brassica oleracea L. var. italica Plenk) were investigated during 3 successive cropping seasons. Plant population had only a slight effect on marketable yield. Spear wt decreased and crop maturity was delayed as plant population increased. Yields were increased and maturity was slightly delayed by N top-dressing. The optimum period for single-harvested extended over 3 to 4 days and began when about 11% of the spears were over-mature.

Machine-harvesting of broccoli, a prime goal of the industry, may be achieved by development of a cultural system adapted to a single-harvest. Greater plant populations have increased single-harvest yields of many vegetable crops. Several studies have been conducted on the effects of plant populations on the yield of broccoli (1, 7, 9, 11), however, plant population was increased by reducing the within-row spacing at constant between-row distances and the crops were sequentially harvested as the spears matured. Single-harvest yields were about the same for different plant populations in a trial conducted by Campbell et al. (4) with cv. Coastal, where the plants were spaced at 25.4, 15.2, and 7.6 cm in rows 106.7 cm apart. However, Palevitch (8) obtained increased yields with 'Spartan Early' by increasing the plant population, especially with spacings approaching equidistant arrangements. Also, Kraus (6) found that plant population markedly affected single-harvest broccoli yields and suggested optimum plant spacing for mechanical harvesting probably will be between 38.1 x 7.6 cm (345,350 plants/ha) and 38.1 x 30.5 cm (86,060 plants/ha) with average yield expectations of 7.8 to 9.0 tons/ha.

The objective of this study was to investigate yield-plant population relationships for once-over mechanical harvest of broccoli. Factorial experiments, comprised of 10 spacing treatments, 3 rates of N, 3 harvest dates, and 2 replications were conducted during each of 3 growing seasons. 'Primo' was used in 1968 but, because of unavailability, 'Gem Hybrid' was used in 1969 and 1970. Seed was sown in outdoor beds in early to mid-June each year. Plants were pulled at approx 5 weeks and transplanted in a systematic fan design extended to fill a rectangle as described by Bleasdale (2) with fan orientation varied at random. The soil was a fine sandy loam and fertilizer was added prior to transplanting in keeping with the N, P and K requirements of broccoli as defined for conventional spacing and sequential harvesting in the area (5). N treatments were applied as a broadcast top dressing of ammonium nitrate 15 to 20 days after transplanting at the rates of 0, 90 and 180 kg N/ha in addition to a proton application of 90 kg/ha for all treatments. A preventative insect control program was followed and the plots were not irrigated.

The crop was single-harvested when 3 to 5% of the plants flowered. Later harvests followed at 4-day intervals in 1968 and 1969 and at 3-day intervals in 1970. All plants except those in guard rows and at row ends were harvested. The spears (central inflorescences) were graded and those considered to be marketable were cut to 15 cm lengths and weighed. Spears with open flowers were classed as over-mature and the percentage of out-of-grade were converted into angles for statistical analysis.

Marketable yields. Plant spacing had very little effect on single-harvest marketable yields within the range of spacings tested (Table 1). N rate had the most marked effect on marketable yields (Table 1). Plots that were top-dressed with 90 kg N/ha, in addition to the basic fertilizer application, produced 2.01 tons/ha more than those receiving the basic fertilizer only. Top-dressing with 180 kg N/ha resulted in greater yields than the 90 kg N/ha rate, but the difference was not significant.

Marketable yields increased at later

Literature Cited
harvest dates (Table 1), with the greatest increase occurring between the 1st and 2nd harvest dates. The yield increase between the 2nd and 3rd harvest dates was not significant.

**Spear wt and % spears marketable.**

The decrease in spear wt with increasing plant population was directly proportional to the decrease in area available for individual plants within the range of 58,230 to 131,490 plants/ha (Table 1). Top-dressing with N at rates of 90 and 180 kg/ha increased spear wt by 23.1 and 31.3%, respectively. Spear wt, in general, increased as harvest date progressed. There was a highly significant harvest date x plant population interaction effect on spear wt. Harvest date, at high plant populations, had very little effect on spear wt (Table 2); while harvest date, at low plant populations, had a pronounced effect.

Although harvest dates had no significant effect on % spears marketable, spacing and rate of N did have an influence (Table 1). At lower plant populations, % spears marketable at a single-harvest was not greatly influenced by spacing (Table 1). However, as plant population increased beyond 131,490 plants/ha, % spears marketable decreased. Plants top-dressed at the rates of 90 and 180 kg N/ha produced 5.2 and 5.6% more marketable spears, respectively, than those receiving the basic fertilizer only.

**Maturity.** Plant population affected maturity. Over-mature spears decreased from approx 16% in the low to about 9% in the high population treatments (Table 1). This delay in maturity was almost as great as the delay between the 1st and 2nd harvest dates (Table 1), about 3 days. Maturity, also, was slightly delayed by top-dressing with N (Table 1). It was estimated, on the basis of the effect of harvest date on % spears over-mature, that the delay in maturity resulting from either rate of N top-dressing was about 1 day.

**Discussion.** These results indicate that single-harvest marketable yields of broccoli of about 6.7 tons/ha can be expected with 'Primo' or 'Gem Hybrid'. Campbell et al. (4) obtained single-harvest yields of 5.5 tons/ha with 'Coastal', and Palevitch (8) reported yields of up to 8.5 tons/ha in a single-harvest trial with 'Spartan Early'.

In these experiments with 'Primo' and 'Gem Hybrid' optimum plant population with an equidistant pattern based on the least no. of spears to handle and ease of cultivation, appears to be about 62,000 plants/ha (40 x 40 cm). Palevitch (8) obtained the greatest single-harvest yield with 'Spartan Early' at a population of 111,000 plants/ha in an equidistant planting.

The increased marketable yields resulting from a top-dressing of N indicates that broccoli may benefit from higher rates of applied N when single-harvested than when harvested sequentially. However, the lack of a spacing x rate of N interaction effect on marketable yields indicates that the high population plantings did not benefit from greater rates of applied N than the low population plantings. A direct comparison cannot be made because the lowest population was 38,760 plants/ha in these trials while earlier research with N (5) was conducted with 17,930 plants/ha. Zink (10) reported greater yield increases from high rates of N at high plant populations than at low plant populations, but the crop was sequentially harvested.

Single-harvest yields increased at the calculated rate of approx 335 kg/ha/day during the 3 or 4-day period between the 1st and 2nd harvest dates. Brendler (3) reported a yield increase of approx 336 kg N/ha/day for a few days before peak yield.

To obtain max single-harvest yields, harvest must be delayed until at least 11% of the spears are over-mature (Table 1). Yields remained relatively constant during the 3 or 4-day period between the 2nd and 3rd harvest dates. Therefore, it may be concluded that the optimum harvest period extends over a 3 or 4-day period beginning and ending when about 11 and 23%, respectively, of the spears are over-mature. Campbell et al. (4) reported increased single-harvest marketable yields from a delay in harvest until 10 to 15% of the heads were over-mature. The delay in maturity at higher plant populations reported here is in keeping with the results of spacing trials presented by Krause (6).

The data presented indicate that broccoli is adaptable to a single-harvest; machine-harvesting, the prime goal of the industry, is considered feasible.

**Table 1. The effects of plant population, rate of N, and harvest date on spear wt and maturity of single-harvested broccoli. Data are averages of 1968 ("Primo"), 1969 and 1970 ("Gem Hybrid").**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Marketable yield (metric tons/ha)</th>
<th>Spear wt (g)</th>
<th>Spears marketable (%)</th>
<th>Spears over-mature (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spacing (cm)</strong></td>
<td><strong>Plants/ha</strong></td>
<td><strong>20.3 x 20.3</strong></td>
<td>242,230</td>
<td>22.6 x 22.6</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------</td>
<td>--------------</td>
<td>-----------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>0</td>
<td>4.96 b</td>
<td>90.8 a</td>
<td>67.5 b</td>
<td>14.6 a</td>
</tr>
<tr>
<td>90</td>
<td>6.97 a</td>
<td>113.9 b</td>
<td>72.7 a</td>
<td>12.0 a</td>
</tr>
<tr>
<td>180</td>
<td>7.43 a</td>
<td>122.1 a</td>
<td>73.1 a</td>
<td>11.8 a</td>
</tr>
<tr>
<td><strong>N top-dressing (kg/ha)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>5.55 b</td>
<td>91.2 c</td>
<td>70.5 a</td>
<td>3.7 c</td>
</tr>
<tr>
<td>2</td>
<td>6.78 a</td>
<td>111.7 b</td>
<td>73.7 a</td>
<td>11.4 b</td>
</tr>
<tr>
<td>3</td>
<td>7.03 a</td>
<td>123.9 a</td>
<td>69.2 a</td>
<td>23.3 a</td>
</tr>
</tbody>
</table>

Table 2. Interaction effect of plant population x harvest date on mean spear wt of single-harvested broccoli. Data are averages of 1968 ("Primo"), 1969 and 1970 ("Gem Hybrid").

<table>
<thead>
<tr>
<th>Mean spear wt (g)</th>
<th>Plants/ha</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
</tr>
</thead>
<tbody>
<tr>
<td>242,230</td>
<td>43.1 a²</td>
<td>42.2 a</td>
<td>46.3 a</td>
<td></td>
</tr>
<tr>
<td>197,600</td>
<td>54.9 a</td>
<td>48.6 a</td>
<td>48.6 a</td>
<td></td>
</tr>
<tr>
<td>161,190</td>
<td>51.8 a</td>
<td>57.7 a</td>
<td>59.5 a</td>
<td></td>
</tr>
<tr>
<td>131,490</td>
<td>63.1 a</td>
<td>75.4 a</td>
<td>76.3 a</td>
<td></td>
</tr>
<tr>
<td>107,270</td>
<td>79.9 b</td>
<td>84.9 a</td>
<td>97.2 a</td>
<td></td>
</tr>
<tr>
<td>87,530</td>
<td>85.8 c</td>
<td>103.1 b</td>
<td>119.9 a</td>
<td></td>
</tr>
<tr>
<td>71,400</td>
<td>100.8 c</td>
<td>128.0 b</td>
<td>140.7 a</td>
<td></td>
</tr>
<tr>
<td>58,230</td>
<td>131.7 c</td>
<td>164.3 b</td>
<td>190.2 a</td>
<td></td>
</tr>
<tr>
<td>47,510</td>
<td>153.5 c</td>
<td>173.9 b</td>
<td>210.2 a</td>
<td></td>
</tr>
<tr>
<td>38,760</td>
<td>167.5 b</td>
<td>238.8 a</td>
<td>249.7 a</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Interaction effect of plant population x harvest date on mean spear wt of single-harvested broccoli. Data are averages of 1968 ("Primo"), 1969 and 1970 ("Gem Hybrid").

*Means within a column followed by the same letter are not significantly different at the 5% level according to Duncan’s Multiple Range test.*

*790 kg N/ha applied preplant to all treatments.*

**Literature Cited**


Influence of Gibberellin on Time of Bud Development in Globe Artichoke¹,²

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Abstract. Gibberellic acid (GA₃) was applied to globe artichoke plants prior to bud enlargement in the fall, and to similar plants during bud development in the spring. Single applications of 25 or 50 ppm were adequate to induce accelerated flower bud development. The rate of bud development was more pronounced when GA₃ was applied in the fall. Although total yields from treated and non-treated plants were not significantly different, earliness was increased.

The globe artichoke, *Cynara scolymus*, cv. Green Globe, is grown commercially as a perrenial in several coastal areas of California. The edible portion of the developing flower bud, which includes the bud scales (bracts) and the receptacle, is of importance commercially. This is commonly referred to as a "choke" or "buds", the latter term is used in this paper. Bud production is continuous throughout the year, although 60-70% of the crop is concentrated in the spring. It would be commercially desirable to spread the production of this crop, preferably to earlier periods such as the late fall and late winter. Producers overcome this crop glut in part by removal of matured flower stalks which allows a continuous development of new shoot and bud growth. Unfortunately, this practice, although it increases total crop production, does not improve the pattern of bud production. After the spring crop the entire plant usually is cut back. Regrowth occurs during the late summer, and bud production is resumed by early October. Winter production is limited due to the low no. of buds produced and due to the low temperatures which affect growth from late November through early March. With higher spring temperatures, a larger no. of buds develop, thereby causing overproduction. Earlier development of buds would help to minimize this problem.

Because of reports that GA₃ stimulated both flower production and vegetative growth in some plant species under cool conditions (1,6,9,10,11) we initiated out studies with globe artichoke to determine whether it would enhance bud production without harmful effect on quality, yield, and plant growth. Subsequent reports (5, 7, 12) made during and following our study have supported our conclusions.

In France, Pochard (8) indicated GA₃ application modified bud shape and gave a 5 to 15 day advance in maturity. In Italy, Marzi (7) and Casilli (2,3) reported that GA₃ advanced marketable maturity as much as 60 days. Recently, DeAngelis (4) in Israel reported that repeated autumn sprays of GA₃ at rates of 120 ppm resulted in advanced bud development. Commercial usage of GA₃ on artichokes has been attempted successfully in both Israel and the United States within recent years.

Our experiments were conducted in commercial fields in the Guadalupe, Morro Bay, and Castroville areas of California between 1958 and 1968. Except for the application of GA₃, cultural practices were those common to the production area. Four or more replicated plots were used in each experiment, with 1 to 10 plants per plot. The potassium salt of GA₃ was applied to the plants in an aqueous solution containing a sticker spreader. The plants were sprayed, using a coarse pressure hand sprayer, until the solution dripped from the foliage. Various rates of GA₃, from 25 ppm to 1000 ppm, were applied at different seasons and stages of growth. In some instances, multiple applications were made. The buds were harvested as they reached marketable stage.

Application of GA₃ resulted in increased production of early, marketable buds as compared to untreated plants, regardless of time of application (Fig 1,2). Production ranged from 10 days to 5 months earlier than the untreated. For example, in the 1959-1960 Guadalupe test an average of 11.4 buds per plant was obtained in October with the 100 ppm GA₃ application as compared to the untreated plants, which took until March to produce 12.6 buds (Table 1; Figure 1B). The difference in early bud production between treated and untreated plants was most pronounced during the winter and early spring. Usually a 6 to 8 week advance in average dates of maturity occurred. However, in the late spring, toward termination of production, the gap in time of maturity diminished in all trials; and in some instances a reversal occurred in which buds from non-treated plants matured earlier. Although the seasonal patterns of yield were not different in the various treatments, the average yield for the whole season did not differ significantly between treatments.

Rates of 25 to 100 ppm GA₃ were adequate to induce an increase in early bud production. Higher rates and high rate multiple applications had little effect on total no. and total wt of buds except in the 1958-1959 Guadalupe experiment. In that experiment, application of 1000 ppm GA₃, repeated 4 times, significantly reduced total bud wt (Table 1). In addition, average bud wt at the 1000 ppm rate was 0.20 lb compared to 0.24, 0.27 and 0.30 lb at the 0.10 and 100 ppm rates, respectively. In the other experiments, average bud wt was not correlated with dosage level, although a greater no. of small sized and cull buds tended to be associated with the highest rate used. Differences in yield response, either in no. or wt, induced by rates of 25 and 100 ppm could not be separated from seasonal effects, cultural procedures, or possibly initial size of the plants.

Specific differences in bud quality were not observed in any of the experiments, except at 1000 ppm applied 4 times, in the 1958-1959 Guadalupe trial. This treatment produced excessive internodal lengths of bearing stems, elongated and misshapen buds, and lighter colored foliage.

Persisting effects of GA₃ application on subsequent plant growth or production were not detectable in any of the trials conducted. Regrettably, we did not observe repeated annual treatments on the same field.

We conclude that single application of 25 or 50 ppm of GA₃ to globe artichoke plants approx. 6 weeks prior to anticipated harvest increased bud production during normally cool seasons.

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²The cooperation of T. M. Aldrich, T. M. Little and L. L. Rappaport in conducting this study is gratefully acknowledged.
³Farm Advisor, Santa Barbara County, Santa Cruz County, and Extension Vegetable Specialist, respectively.