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Offshoots vs. Stumps as Planting Materials for Globe Artichokes[1]

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Abstract. **Yield/plant of both stump-planted and offshoot-planted globe artichokes (*Cynara scolymus* L.) decreased as spacing decreased, but total yield increased. Highest yields were obtained at intermediate levels of number and spacing of shoots: 6 shoots/location at 1.2 x 1.2 m and 3 shoots/location at 1.2 x 0.9 m. Early yield of offshoot-planted artichokes was 7x that of stump-planted artichokes. Production from offshoots occurs in 2 discrete periods, a moderate yield 4 months after planting and a heavy yield during months 9 and 10. Production from stumps increased very slowly, peaking during the last 3 months of the experiment.**

Globe artichoke production in California began in the 1880s. Since 1920, most of the U.S. production has been around Castroville, California and this area now produces 90% of the U.S. crop. 'Green Globe' is the only cultivar grown, except for a few hectares of a new cultivar, 'Magnifico' (6).

Artichoke production practices are unique. In California, the plant is vegetatively propagated with basal stem pieces, usually called stumps or crowns, that have attached roots and shoot buds. Regrowth from one or more buds occurs; shoots are produced that may be vegetative or reproductive. The shoots form roots and become established as individual plants, which later also initiate buds that become shoots; this process continues through the year and from year to year. The number of shoots and size of the shoot group become very large after several years (Fig. 1).

The shoots themselves may be used as planting stock, a practice commonly followed in France and Italy. When removed from stumps for this purpose, usually with a few roots, they are known as offshoots.

Growers replant their fields with stumps from plants that have been cut down in older fields. Two or 3 stumps are planted at each location or hill to ensure a good stand. The number of shoots that develop depends on the number of surviving stumps and the number of buds that produce shoots. The number of shoots is usually excessive and leads to over-production of vegetative shoots that compete with the reproductive shoots that produce the edible flower buds or "chokes".

Artichoke fields are planted at low density. Common spacings are 2.4 x 2.7 m (8 x 9 ft) and 1.4 x 3.0 m (4.5 x 10 ft). These spacings permit mechanized cultural operations between the rows and between plant locations within the rows but restrict the number of locations per unit area. Each location occupies 6.5 and 4.5 m^2, respectively, at these spacings.

Growers replant their fields when productivity and crop quality decrease, or when damage by the artichoke plume moth or other pests increases sufficiently to restrict income. Fields are seldom replanted in fewer than 5 years and may remain in production for 10 years or longer. Artichokes are usually replanted into fields in which artichokes were grown the previous year because available land is limited to a relatively small, climatically favored area, and because the unique cultural practices prevent easy rotation with other crops.

The problems of productivity, quality and pest damage accruing from these cultural practices led the artichoke industry to establish a research program to resolve several problems including those of cultural practice modification. The program is financed by the Artichoke Research Associaton, a non-profit grower-supported organization, in cooperation with the U.S. Department of Agriculture and the University of California. The program was begun in 1974 and also includes plant breeding and entomological research.

The overall goal of the program is to improve productivity and quality. One means of increasing production is to increase plant population by closer spacing of smaller plants. This paper reports results of a series of experiments comparing stumps vs rooted offshoots planted at various spacings.

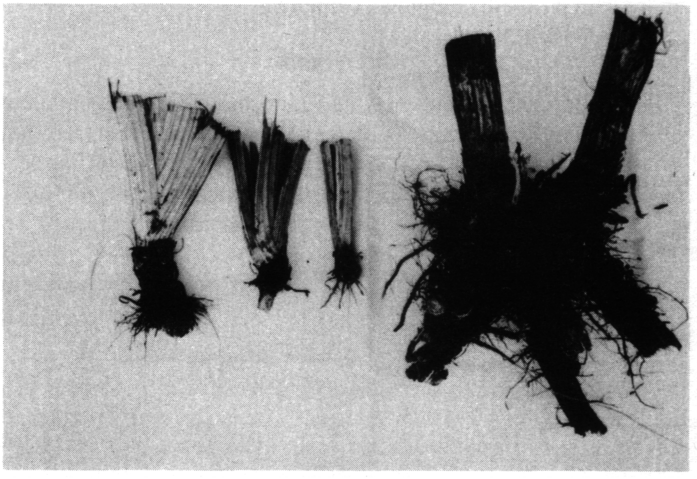

Fig. 1. Artichoke planting stock. On left are 3 offshoots, center shoot is ideal for planting. On right is stump showing 2 stalks (about 5 cm in diameter), large secondary roots, and fibrous roots.

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Materials and Methods

Stump spacing. This study compared closer-than-traditional spacings of traditional planting material, on the thesis that increased plant population per unit of land will increase total production. Spacings were 1.2 x 3.1 m (4 x 10 ft), 1.2 x 1.5 m (4 x 5 ft), and 1.2 x 0.8 m (4 x 2.5 ft). Single stumps were planted on July 4, 1975. Each treatment, replicated 4 times, consisted of 2 rows 76.2 m long, arranged in a randomized complete block design.

Yield, recorded as number of marketable chokes per plant, was taken from 30 plants of each replicate for each spacing. Four harvests at weekly intervals were made between April 12 and May 4, 1976. Surviving plants, and surviving plants that produced artichokes, were counted. The mean number of productive shoots per plant was determined based on 10 randomly chosen plants.

Effects of shoot number and spacing. In commercial plantings, 2 or 3 stumps are planted at each location to ensure a complete stand. This practice results in an excess of shoots at each location, the number depending upon the number of surviving stumps.

We compared 5 within-row spacings, 0.6, 0.9, 1.2, 1.5, and 1.8 m, in rows 1.2 m apart. At each spacing, 1, 2, 3 or 5 stumps, each producing at least 2 shoots, were planted and thinned as appropriate to leave 1, 3, 6 or 10 shoots at each location. There were 4 replications.

Harvest data were taken from 30 locations per treatment per replicate and yield/hectare was calculated. The average percentage of surviving productive plants and number of reproductive shoots/location were determined for each treatment. The experiment was planted July 8, 1975 and terminated after 9 months.

Offshoots vs. stumps as planting materials. Single offshoots and stumps with one shoot each were obtained from a commercial field for comparison of earliness and yield. These materials were planted in single- and double-row beds in 4 replications. Rows were 36.6 m long and 2.4 m apart. In single rows, plants were placed 0.9 m apart in the center of the bed, with 41 plants/row. In double rows, 0.9 m apart on beds, plants were placed 0.9 m apart in each row, with each plant opposite a space in the other row, for a total of 82 plants/bed. The planting date was July 4, 1975 and the experiment was terminated after 9 months.

Offshoots vs. stumps in single row beds. Materials were obtained from commercial fields. Single stumps and offshoots were placed 0.9 m apart in rows 2.4 m apart. Each treatment consisted of 63 locations/row. Earliness and total yield were recorded. Chokes were divided into three size (grade) groups in terms of number of chokes/box. The experiment was planted June 9, 1976 and terminated May 21, 1977. There were 4 replications.

Offshoot spacing. Single offshoots were planted 0.3, 0.6 and 0.9 m apart in rows 36.6 m long and 2.4 m apart, and in 4 replicates. The experiment was planted July 28, 1977 and terminated March 20, 1978 after 7 harvests. Total yield and grade distribution were determined.

Separated vs. attached shoots. Stumps with 3 or 4 attached shoots were planted 2.7 m apart in rows 2.4 m apart. These were compared to 3 or 4 offshoots planted separately at the same spacings. At each location, 3 separated offshoots were placed in a triangular orientation, 30.5 cm on a side. Four were placed in a square also 30.5 cm on a side. Total yield per location was recorded and projected on a hectare basis. The planting date was June 27, 1977; after 13 harvests the experiment was ended on February 24, 1978.

Results and Discussion

Stump spacing. The yield per plant increased with wider spacing (Table 1). However, on a unit area basis, the yield was greater at the closer spacing. At 0.8 m, the yield (kg/ha) was 104% greater than at 3.1 m and 72% greater than at 1.5 m. Similar yield responses were recorded by Dellacecca and Marzi (3).

Commercial fields are usually planted with 2–3 stumps/location to ensure a good stand. As this experiment was planted with only one stump/location, the mortality was high and the number of producing shoots/location was low.

Effects of shoot number and spacing. In commercial fields 4 years and older, there are, on the average, 50 shoots/location. Counts in 1500 hills showed that only 4 shoots, on the average, actually produce artichokes. The rest produce only foliage. It may be that early reproductive shoots maintain some dominance, preventing reproductive development of later ones.

Regardless of the total number of shoots at each location, only 1 or 2 actually produced artichokes (Table 2). The highest yields were from 6 shoots/location at 1.2 x 1.2 m and 3 shoots/location at 1.2 x 0.9 m. The lowest yields were at the extremes of 1 or 10 shoots/location. Overall, the best yields were: 1) at 0.24 – 0.48 m^2/shoot and 2) with 3 or 6 shoots/location. In present commercial practice, density is about 0.08 – 0.09 m^2/shoot, or 12 shoots/m^2. Shoots are, of course, not evenly distributed but clustered in locations, averaging, as noted earlier, 50 shoots/location.

These comparisons, using only traditional planting materials (stumps producing shoots), show an improvement in productivity resulting from increased planting density compared to commercial practice.

An additional improvement was obtained by reducing the total number of potentially competing shoots. When a stump was planted with one shoot, that shoot became productive. When a stump had 3 or 6 shoots, on the average only 2 became producing. Stumps with 10 shoots still averaged only 2 producing shoots. The competitive factor introduced by the large number of vegetative shoots probably had a depressing effect on yield. An intermediate number of shoots/stump seemed to be most productive.

Offshoots vs. stumps as planting materials. Twenty-three weeks after planting, 48% of the plants from offshoots in single rows and 40% from offshoots in double rows had produced artichokes (Table 3). This compares to 7% and 6%, respectively, from stumps in single and double rows. As a result, the offshoots produced a greatly superior early yield. After 36 weeks, the yields were more nearly the same, although at this stage, yield from single row stumps exceeded that from single row offshoots.

Offshoots vs. stumps in single row beds. Results were similar to those of previous experiment. After 4 months (125 days), offshoot yield exceeded stump yield by 2½ times (Table 4). After 8 months (237 days), the total yield was about the same. After 9

Table 1. Yield, survival rate and production efficiency of artichokes planted as stumps at various spacings. (between row spacing 1.2 m, total of 4 harvests, 1975-76).

Within row spacing (m)	Yield/plant (kg)	Yield (kg/ha)	Surviving plants (%)	Surviving plants with buds (%)	Producing shoots/hill
0.8	0.78	8160C[z]	87	79	1[y]
1.5	1.24	6900B	82	88	2
3.1	1.49	4010A	81	85	1

[z]Mean separation by LSD, 1% level.
[y]Mean of 10 plants.

Table 2. Effect of number of shoots per location and spacing on yield, survival rate and production efficiency of artichoke planted by stump method (between row spacing 1.2 m, 1975-76).

No. shoots/ location	Within row spacing (m)	Yield (kg/ha)[z]	Surviving plants (%)	Surviving plants that produced buds (%)	Area/ shoot (m^2)	Producing shoots/ location
1	0.6	6360 a	91	71	0.72	1
	0.9	6570 ab	86	79	1.08	1
3	0.9	9310 c	98	93	0.36	1
	1.2	8800 bc	91	83	0.48	2
6	1.2	9540 c	86	100	0.24	2
	1.5	8310 abc	86	95	0.30	2
10	1.5	6640 ab	97	88	0.18	2
	1.8	6840 ab	99	98	0.29	2

[z]Mean separation by LSD, 5% level.

months (271 days) the stump yield was double that of offshoot yield and after 10 months (315 days), the yield was again the same. Offshoot production occurred in 2 discrete relatively short periods. About 15% of the production was produced in the 4th month and about 80% in the last 2½ months of the 11 month experiment. Production from stumps was less concentrated; it was sparse at first, with the heaviest concentration, about 85%, in the last 3⅓ months.

The fact that yield occurred in 2 concentrated periods suggests that artichokes produced from offshoots could be harvested more efficiently and with less expense than those produced from stumps and suggests also the possibility of mechanical harvesting. Furthermore, offshoots planted annually can produce 2 crops a year. On the average, present practices yield 2 crops every 3 years. Attia and El-Din (2) and La Malfa and Foury (5) also found significant early production from offshoots compared to stumps. However, Dellacecca and Pace (4) found no difference.

Size distribution of harvested artichokes in this experiment was essentially the same for both types of planting (Table 4). The distribution of sizes at each harvest varied considerably but there was no fixed pattern. This may have been due to low numbers and/or environmental variation.

Offshoot spacing. As with the stump planted experiment described above, total yield increased with increased density although yield/shoot was lower at the closer spacing (Table 5).

The area for each shoot at the 3 spacings was 0.7 m^2 at 0.3 x 2.4 m, 1.4 m^2 at 0.6 x 2.4 m and 2.2 m^2 at 0.9 x 2.4 m. Results from the experiment "Effect of shoot number and spacing" indicated that 0.24–0.48 m^2/shoot was the most desirable planting density (Table 2). The closest spacing in this experiment exceeded the optimum density by 3.8 fold and exceeds that used in a commercial field by 10x, but this is based on the number of shoots/unit area, not on the number of locations/unit area. The number of shoots/unit area in a commercial field is high because of the large number of shoots/location.

Grade distribution was similar for all 3 spacings, indicating that higher yields at higher densities may not effect choke size. Dellacecca and Marzi (3) also found no decrease in choke size at higher densities. Abdel-Al and Moustafa (1) had similar results, finding that spacing did not affect average choke weight.

To reduce the spacing within the row to less than 0.3 m would place shoots too close together to allow optimum growth. Therefore, reduction of between-row spacing to 0.8–1.6 m would achieve the area/plant ratio suggested above as optimum.

Separated vs. attached shoots. Separated offshoots produced higher yields than attached shoots (Table 6). The highest yield was obtained from 4 separated offshoots, and the lowest from 4 attached shoots. The implication is that attachment introduces an element of competition among a group of shoots and the competition becomes more limiting as the number of attached shoots increases.

Four independent offshoots yielded more than 3 independent offshoots. However, the results of the "Shoot number and spacing" experiment suggested that 4 shoots/m^2 is optimum for yield (Table 2) as compared to either fewer or more. These results indicate an upper limit for density in increasing yield.

Table 3. Artichoke production from offshoots and stumps planted in single- and double-row beds (between row spacing 2.4 m, 1975-76).

Planting stock	Rows	Producing plants, 23 weeks (%)	Yield, 23 weeks (kg/ha)	Yield, 36 weeks (kg/ha)
Stumps	Single	7	450A[z]	6050B[z]
	Double	6	430A	7590C
Offshoots	Single	48	2370B	4960A
	Double	40	3060C	7720C

[z]Mean separation by LSD, 1% level.

Table 4. Cumulative yield and size distribution of artichokes from offshoots and stumps planted in single rows (between row spacing 2.4 m, 1976-77).

Variable	Offshoots	Stumps
Days from planting	*Cumulative yield (kg/ha)*	
125	3,480	1,410
216	4,400	3,390
237	4,560	4,570
271	8,550	16,290
315	22,200	22,720
Size		
Distribution[z]	*Over all harvests (%)*	
24	23	20
54	21	26
63-72	56	54

[z]No. of chokes/standard box.

Conclusions

The results of these experiments suggest several advantages in the use of offshoots instead of stumps as planting materials. Offshoots produce 2 discrete crops, an early one about 4 months

Table 5. Artichoke yield[z] and choke size from offshoots planted at three within-row spacings, (between row spacing 2.4 m, 1977-78).

Within row spacing (m)	Yield of 36.6 m row (kg)	Yield/ offshoot (kg)	Yield (kg/ha)	Size distribution No. of chokes/ standard box 24	54	63-72
0.3	80	0.65	9020 c[y]	17	32	51
0.6	69	1.13	7690 b	15	28	57
0.9	57	1.39	6420 a	17	25	59

[z]Cumulative yield from 7 harvests.
[y]Mean separation by LSD, 5% level.

Table 6. Artichoke yield[z] from shoots planted separately as offshoots and attached to stumps, 1977-78.

Planting method	Shoots/ location	Yield/location (kg)	Yield (kg/ha)
Attached	3	4.1	6200B[y]
	4	3.4	5070A
Separate	3	6.2	9220C
	4	7.6	11330D

[z]Cumulative yield of 13 harvests.
[y]Mean separation by LSD, 1% level.

after planting and at late one 9–10 months after planting. The latter corresponds to the peak production period for stump plantings, which, however, extends over a longer period.

The relative uniformity of the offshoot planting can be increased further by selection of suitable offshoots. These should be uniformly medium sized (2 cm diameter). Larger, older shoots produce early plants that are quite small and have a single small choke, while smaller, younger offshoots produce much foliage and late developing chokes similar to plants from stumps (1, unpublished data).

Offshoots selected for uniformity can be mechanically transplanted. They also can be treated for insects and diseases and easily stored for later planting. Plants from offshoots are smaller and have less foliage, which should permit easier penetration of spray materials and provide less shelter for rodents.

Finally, offshoots can be planted closely spaced in rows. In addition to the potential for higher yields, this practice would permit treating the artichoke as an annual crop and to fit better into rotations with other row crops.

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