PLANT SPACING IN BROCCOLI

—*affects yield, head size, earliness*

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Spacing of plants affects both the total yield and the size of broccoli heads according to recent field tests. These results are important because the freezing industry generally prefers heads of smaller size than those shipped for fresh marketing. The tests indicate that the closer the spacing, the smaller the heads produced. Total yield increased to a maximum when spacing was reduced to 8 or 11 inches (depending on season and variety). Further decrease in the space between plants results in an abrupt reduction in yield.

Two of the tests were conducted in the Arroyo Grande Valley of San Luis Obispo County and two in the Santa Maria Valley of Santa Barbara County in 1959, and again in 1960. Two tests were planted in October, another in July, and another in February. Total yields differed considerably between seasons, but the general trends related to spacing were similar in all four tests.

The relationship between spacing and total yield is complicated but can be simplified by comparing yield per plant with the number of plants per unit area. In all of the tests, there was a uniform reduction in weight of head, diameter of head and diameter of butt as the number of plants per unit area increased. When yields were related to spacing in inches, curves (shown on graph) resulted which were characteristic of much of the yield data obtained by other workers—not only with broccoli, but with other vegetable crops such as sweet corn, tomatoes, lettuce, and peppers.

Graph

The graph shows the effect of different plant spacings on total yield for each test. The optimum spacing for maximum yields in test No. 1 was 11.2 inches; for test No. 2, 7.9 inches; for test No. 3, 8 inches; and for test No. 4, 9.4 inches.

The yield curves show that extreme caution is necessary in avoiding too close a spacing. The total yield drops off very rapidly when the spacing is reduced only a few inches below optimum. There is, however, quite a wide range of spacings above the optimum where the yields are very little affected because the reduction in number of plants per acre is almost offset by the increase in yield per plant.

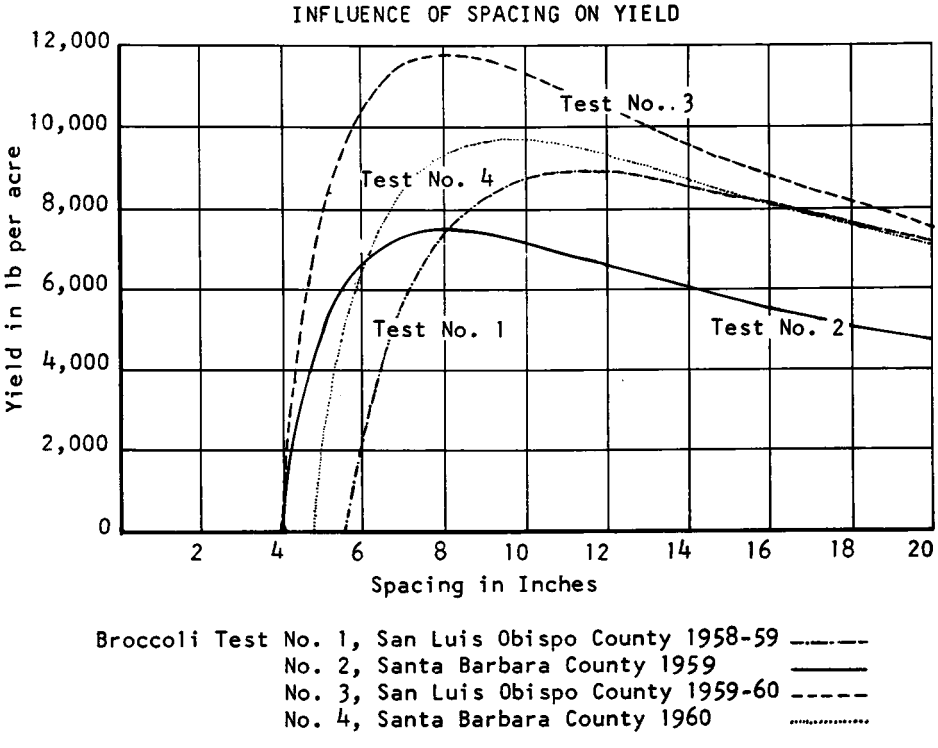
One of the surprising results was the effect of different spacings on rate of maturity. Compared with the closer spacings, the wider spacings produced a higher proportion of their total yield early in the season, in three out of four tests. This may have been due to the fact that under close spacing some of the plants are heavily shaded and, hence, their maturity is delayed until the adjacent plants are harvested.

Spacing and size

The spacing which produces the best yield may not necessarily be the spacing which would produce the most desirable sizes for a given market. If large-sized heads bring a premium, a wider spacing might be desirable and would result in only a small sacrifice in total yield. On the other hand, if small sizes are needed, as might be the case with freezers, closer spacing would be indicated.

Broccoli size in test No. 1 increased from a head diameter of 2.87 inches and butt diameter of 1.38 inches at the 10-inch spacing to a head diameter of 3.39 inches and butt diameter of 1.53 at 20 inches. In test No. 2, head diameter increased from 3.18 inches at 6-inch spacing to 3.82 at 14-inch spacing, while butt diameter went from 0.87 to 1.06 inches. In test No. 3, head diameter increased from 2.78 inches at 8.5-inch spacing to 3.23 inches at the 15-inch spacing, while butt diameter went from 1.18 inches to 1.30 inches. In test No. 4, head diameter increased from 3.70 inches at the 8-inch spacing to 4.14 inches at 14-inch spacing, while butt diameter went from 1.02 inches to 1.16 inches.

A fairly accurate control over the size of broccoli produced can be obtained by



regulating the spacing, according to these test results. The closer the spacing, the lower the weights per plant, the smaller the diameter of heads and butts, and the later the average maturity. Maximum yields were obtained at spacings of from 8 to 11 inches, depending on the season and the variety grown. The relationship between spacing and total yield indicates that it is safer to err in the direction of spacings that are slightly greater than optimum rather than in the other direction.

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BIOLOGICAL CONTROL OF PUNCTURE VINE

with imported weevils

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Puncture vine, *Tribulus terrestris*, was sufficiently abundant to attract attention as a pest in California around 1912–1915. The weed became so troublesome by 1925 that a basic plan for its control was developed by the California State Department of Agriculture and was adopted in most sections of the state. Expenditures by county governments alone, from 1927 to 1930 inclusive, totalled more than half a million dollars.

Substantial sums were still being spent to control this pest in the early 1950's by county weed control officials. The Association of County Agricultural Commissioners passed a resolution in 1956 requesting research on the possibilities of biological control. Prior to this, Dr. G. W. Angalet of the U. S. Department of Agriculture had been in India exploring for parasites of the oriental fruit fly. He noted the rarity of puncture vine in India and made extensive observations on two species of weevils he found attacking it. His tests and additional research conducted at Albany (by Huffaker) and later in France and Italy by Drs. Angalet and Lloyd Andres established the safety in introduction of both the stem boring weevil, *Microlarinus lypriformis*, and the seed weevil, *Microlarinus lareyniei*. These insects were shown to be entirely incapable of breeding on any plants other than puncture vine and possibly its very close relative, *Kallstroemia* sp. Officials of both the federal and state governments then approved introduction of these insects.

It is much too early in the research program to even guess at how well the weevils imported last summer will work to eventually control puncture vine in California. But limited samples of seed pods and stems taken this fall have already indicated 30 to 50 per cent infestation on some plants at release sites in counties from San Joaquin to Riverside. Next year, if the weevils get off to a good start, it is expected that all interested counties can be supplied with initial stocks for wider distribution of the stem boring weevil, Microlarinus lypriformis, or the seed weevil, Microlarinus lareyniei. Both insects breed only on puncture vine.

Importation

Importation and establishment of these biological control agents were initiated during the summer of 1961. Because of the need to be certain that only these species would be introduced, rather small-scale importations were planned. Since positive identification of each specimen had to be made while it was alive, it was not practical to handle large numbers of the imported weevils. From 800 to 1,000 insects of each species were to be imported, with approximately half of these to be released in California.

The first shipment from Dr. Andres was received on July 11, 1961 and colonizations from this and subsequent shipments were made in July and August, 1961. Seed weevil distributions of about 100 adult insects were made in San Joaquin County near Manteca, Kern County near Bakersfield, and Los Angeles County near Castaic. Two larger colonies of 200 adults each were released near Hughson in Stanislaus County and at Riverside. Stem weevil colonies of 100 adults each were released near Clovis in Fresno County, near Woodville in Tulare County, near Moreno in Riverside County, and at Madera.

Weevils were in egg deposition when the releases were made. In general, half of each colony was released in a cage over a field stand of puncture vine and the other half released outside the cage. After about one month, at which time progeny were beginning to emerge, the cages were removed. While these cages were intended to provide protection to the beetles, they actually proved to be an impediment.

Progress varied

Progress of the weevil colonies has varied greatly. Multiplication from the small numbers of seed weevils released at the Hughson plot in Stanislaus County has been phenomenal. Most of the multiplication came from the first release of 100 weevils on July 13, because a later release of 100 was too late to accomplish a marked reproduction. At this site adult weevils could readily be found in early September beneath the large puncture vine plants at distances 50 to 60 yards from the exact release spot. A conservative guess is that from 25,000 to 100,000 weevils were produced during the two-month period involved, predominantly from the 50 females of the original release. While minimal developmental time was only 22 to 23 days during July and August, since the egg-laying females are long-lived, two full generations were not completed during the time involved, even though some of the population may be of the F_3 generation.

Seed weevils

The Riverside colony of the seed weevil also progressed almost as well. But due to a much more limited supply of host plants, the total multiplication appears to have been less than at the Hughson location. However, reproduction continued approximately one generation longer at this more southern location and higher rates of pod infestation were encountered. Eight hundred weevils emerged from one large plant after it was dug up and caged. Progress of this species was also promising at the Los Angeles County site but