

Stage	Degree of susceptibility	Appearance
0	Host immune	No uredosori developed. Hypersensitive flecks present, but no hyphae in host tissues.
1	Host very resistant	Uredosori abortive and isolated, surrounded by sharply defined necrotic areas.
2	Host moderately resistant	Uredosori small and isolated. Surrounded by necrotic rings within a green island, which may be proximally chlorotic.
3	Host moderately susceptible	Uredosori medium-sized. Chlorotic patches present.
4	Host very susceptible	Uredosori large, numerous, in extensive clusters. Large chlorotic areas.

Of the imported material so far received, five varieties from Mexico show promise of suitability as sources of resistance for the synthesis of varieties adapted to West African conditions.

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⁴ Manners, J. G., *Ann. App. Biol.*, **37**, 187 (1950).

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Effects of Close Spacing on the Growth of Garden Beet

THAT close spacing restricts the growth of most plants is so obvious as not to require experimental proof. Horticulturally, this is a problem of considerable interest because it means that attempts to increase yields by increasing the plant density are not successful. With some crops 'yield' may bear no close relation to total growth, but this is not so for most root vegetables. Further, with these crops, it is possible to determine for any locality the population-range which can be depended on to give the maximum yield of salable roots. Thus on a fertile loam in Cheshire maximum yields of long beet are assured if the plant population lies between 70,000 and 135,000 per acre. Corresponding figures for globe beet are 110,000 and 150,000 with a possible extension of the latter figure. Within these population-ranges total yields may change slightly; but the yields of salable roots (after rejection of small ones) remain constant. There is almost and sometimes quite complete dependence of root size on available space. Thus in one experiment on globe beet, plants allotted 90 sq. in. each had a mean root weight of 10.88 oz. A reduction in the space available per plant by 60 per cent reduced the mean root weight by 58.4 per cent. Why the closely spaced plants should be so small is not clear. In our experiments, even at the closest spacings employed, adjacent plants do not suffer deformation by mutual pressure. Neither have we evidence that it would be harmful if they did. Clearly, the restriction in size which results from close spacing is not due simply to lack of 'room'. Three factors of the environment, competition for which may occur with closely spaced plants, are light, water and mineral nutrients (including nitrogen).

With garden beet we may assume that the ratio of root weight to top, that is, lamina plus petiole, will give an approximate measure of the photosynthetic

efficiency of the leaves. It will be approximate because top weight includes petioles the photosynthetic activity of which is likely to be low in relation to their weight, and the spacing may affect the period of active leaf production. Always we find that when the space available per plant is increased, the weight of tops produced per plant increases (but never so markedly as the increase in available space) and the root/top ratio increases. In single experiments it is not always possible to show that the increase in the root to top ratio is statistically significant; consideration of all the available data, however, leaves one in no doubt as to the reality of the increase. But this effect was appreciable only in 1948 and 1950 and was slight in 1949. In 1949, July and August provided 373 hr. of bright sunshine. Corresponding figures for 1948 and 1950 were 259 and 307 hr. Figures for August only are for the years 1948, 1949 and 1950, 89, 192 and 138 hr. respectively. This does suggest that in relatively sunless years at least, mutual shading of the closely spaced plants may be important, and by restricting photosynthesis, may reduce the flow of assimilates to the storage organ. There is certainly the possibility of this because decreases in available space per plant do not result in proportionate decreases in the weight of tops per plant, so that the weight of tops per unit area of ground is greatest when the plants are closely spaced. Alterations in the root to top ratio induced by spacing changes are, however, never so great as are the changes in the weight of tops per plant. It appears, therefore, that root weight is more dependent on or at least related to leaf weight than to 'leaf efficiency' and that competition for light can play only a small part in restricting the growth of the closely spaced plants.

There is no evidence that competition for water could explain the results obtained. In 1948, July and August provided 7.54 in. of rain (following a rainfall of 4.52 in. in June). In 1950, in only one week subsequent to July 1 was the rainfall less than 0.50 in., and the total for July and August was 6.65 in. Rainfall in 1949 was less abundant at 4.11 in. for July and August; but even so no crops showed any of the signs of distress indicative of a water shortage.

Analyses of leaves from eight of these experiments have failed to reveal any statistically significant effect of close spacing on the contents of nitrogen, potassium, calcium or phosphorus in the leaves when the plants are normally manured. In one experiment, close spacing reduced the nitrogen content of the leaves when the plants received no manure, so that there was a significant positive correlation between nitrogen content of the leaves and root weight, and both were dependent upon the space available per plant. When manured, the nitrogen content of the leaves was not affected by the spacing, but the dependence of root weight on available space persisted. This is the result always obtained on manured plots.

It appears, therefore, that while in the absence of manuring close spacing may result in competition for nitrogen, and that competition for light may be operative, the major effects of close spacing on the growth of normally manured plants cannot be explained solely in terms of competition for water, light or the major nutrient elements.

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