Plant Population and Spacing for Sugar Beet

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Before the use of tractors was popularized, the row space (distance between rows) of sugar beet fields had been maintained at about 50–55 cm for long. As bigger machines have come to be used, the row space for sugar beet has increased apparently due to a wider tread used for other crops like potato. At present, row space of 60 cm is customary, but is further increasing to 66 cm.

Increased row spaces imply naturally reduced plant population (number of plants per field area) which have a risk of yield decrease. On the other hand, there has been an apparent tendency of increasing manuring, as a countermeasure for general decrease of soil fertility, and it has been effective in preventing yield decrease under such thinner stand conditions. However, such heavy-manuring culture of sugar beet can not be regarded as desirable, because it causes the lowering of sugar content and quality, even when root yields can be kept at a certain level.

Reflecting such a situation the authors have studied relations between row space and other cultural practices since 1974. Results will be shown briefly.

Comparison between plant population and row space[2)]

Fig. 1 shows effects of plant population and row space on root yields, harvested in August in the course of growth and at the time of harvest. It was found in August that root weight was increased almost linearly with the increase in plant population from 40,000/ha to 100,000/ha. However, at the time of harvest the root weight was lowest with 40,000 plants/ha and highest at 60,000 plants/ha, beyond which no more increase of root weight

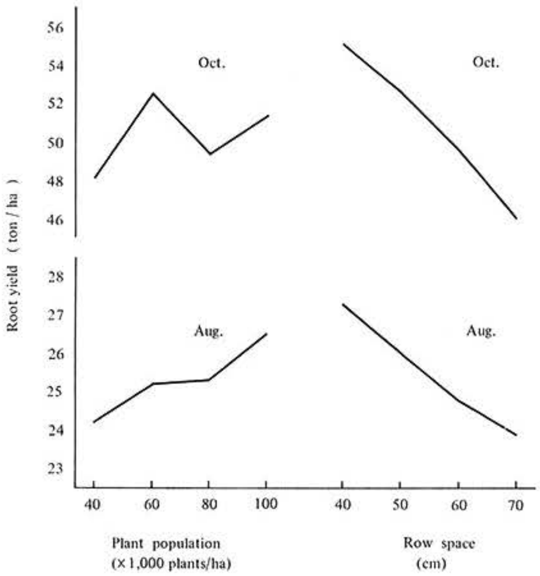

Fig. 1. Effect of plant population and row space on root yield

was recognized with higher plant populations. Namely, although the root weight increases with the increase of plant population during an early half stage of growth, the optimum plant population which gives the highest root yield exists at the time of harvest. Increases of plant population up to this point give increased root yield, but further increase of yield may not always occur beyond this point.

As to the row space, it was made clear that the narrower the row space, from 70 cm to 40 cm, the higher was the root yield at both sampling times, indicating a close, linear relationship irrespective of time.

In actual cultivation, there is a tendency to increase plant population by reducing hill space (distance between plants within a row), instead of reducing row space, aiming at compensating wide row space which is difficult to be changed to narrow one. However, it is clear now that the simple increase of plant population with the wide row space unchanged may not bring about yield increase.

Sugar content is generally increased with the increase in plant population. At the time of harvest, however, it was markedly higher with 60,000 plants/ha than 40,000 plants/ha, but no more increase was observed beyond that population, similar to the case of root weight. Like root yield, the narrower the row space the higher was the sugar content.

Response to hill space[3]

Effect of hill space on root yield at different row space is shown in Fig. 2. At row spaces of 40 and 50 cm, the hill space of 15 cm re-

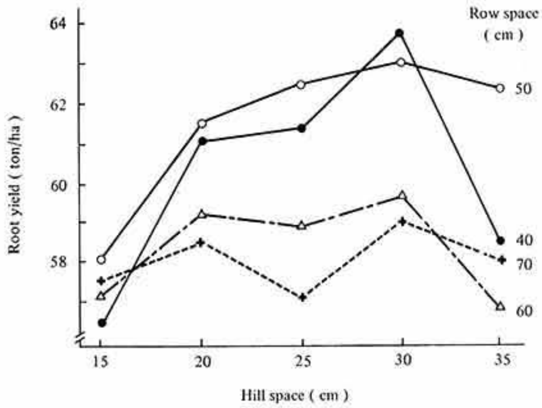

Fig. 2. Effect of hill space at different row spaces on root yield

sulted in extremely low yield, that of 35 cm gave somewhat low yield, while 20, 25 and 30 cm hill spaces gave high yields, particularly 30 cm showed almost the highest yield. At row spaces of 60 and 70 cm, the hill space of 20–30 cm gave relatively high yields, similar to the above result but at a lower yield level.

Sugar content was generally high with 40 and 50 cm row spaces, showing 16.33% in an average from 15 to 30 cm hill spaces, of which almost no difference in sugar content was observed among different hill spaces, but the widest hill space, 35 cm, gave slightly low content (15.96%). With 60 and 70 cm row spaces, the sugar content was highest (16.33% in an average) with 15 cm hill space, and it decreased with wider hill space, reaching the lowest (average 15.40%) at 35 cm hill space.

With 40 and 50 cm row spaces, it was apparent that the optimum hill space lies around 30 cm, but with 60 and 70 cm row spaces no such apparent trend, enough to identify 30 cm hill space as optimum, was observed. As the final product is sugar, sugar yields should be taken up instead of root yields in considering the efficient sugar production. By taking sugar yield = root yield × sugar content, the effect of spacing on sugar yield was examined. The highest sugar yield was obtained with 30 cm hill space at row spaces of 40 and 50 cm, and high yields with 20 cm hill space at 60 and 70 cm row spaces. The optimum hill space differeed slightly with different row spaces.

Using the data shown in Fig. 2, the relationship between plant population and root weight was examined as was done in the preceeding section. Although no relationship between them was recognized when the row space was neglected, certain relationships were found at each level of row space. Furthermore, when the number of plants is same, the narrower the row space, the higher was root yields, indicating that the row space has an important role of determining root yields, rather than its importance in securing number of plants.

Response of varieties[4]

As shown above, the root yield is higher with narrow row space, and when row space is narrow the wide hill space gives higher yield whereas when row space is wide, the narrow hill space gives better yield. Varietal response to this regularity was examined. Varieties used were Monohill, a high yielding E type, and Monohope, a normal N type. Row spaces of 40, 55 and 70 cm and hill spaces, 20 and 30 cm, were combined to make up treatment plots.

With both varieties, root yields showed the order of 20 cm <30 cm of hill space at 40 cm row space, and 20 cm> 30 cm at 70 cm row space. At the intermediate row space, 55 cm, no difference was observed with hill spaces.

Regarding the effect of row space, Monohill showed the highest yield, 58.4 t/ha, at 55 cm row space while Monohope showed the highest, 53.3 t/ha, at 40 cm row space. Both varieties gave low yields at 70 cm. Thus, narrow row space causes higher yield, but varietal difference in optimum row space exists.

Sugar content tends to increase with narrow row space. Monohope and Monohill gave the highest contents at 40 and 55 cm row space respectively, showing a little varietal difference.

Thus, it seems that there is no basic difference in varietal response to spacing. However, it has to be made clear whether the difference observed between the two varieties is caused by different yield levels of them or by specific characteristics of varieties.

Effect of fertilizer application

To examine the effect of fertilizer application on the advantage of narrow row space, 50 and 70 cm row spaces were compared at three levels of fertilizer: standard rate (N 126, P_2O_5 180, K_2O 140 kg/ha), doubled rate and a half rate. Within the range from a half to doubled rate of fertilizer, root weight and sugar content were always greater at the 50 cm row space than at 70 cm row space. At both row spaces, root weight was increased and sugar content was decreased with increasing fertilizer rate, particularly sugar content was markedly decreased with the doubled rate. Sugar yield, as expressed by root yield × sugar

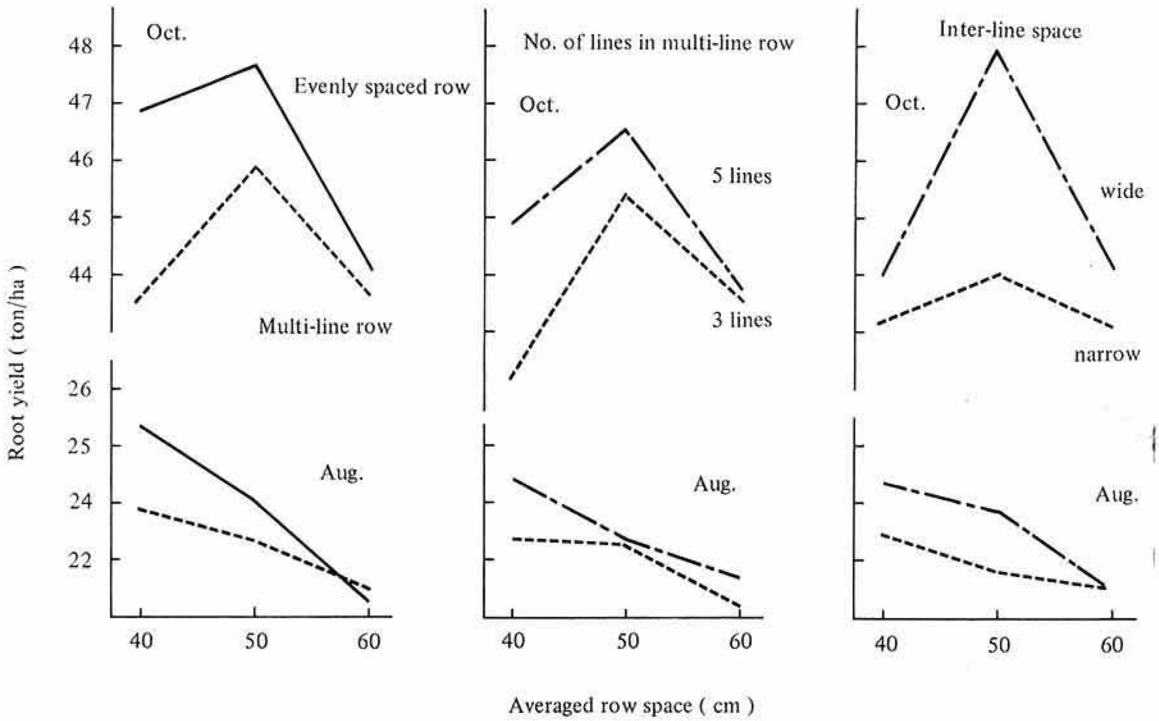

Fig. 3. Effect of planting pattern on root yield

Note: Example of a three-line row with averaged row space of 50 cm

80 (tire) 35 35

150 cm

averaged row space = 150 cm/3 rows = 50 cm content, was always higher with 50 cm than 70 cm of row space, irrespective of fertilizer levels. With 50 cm row space, the standard rate gave the peak yield, while with 70 cm row space no peak yield was shown in the range of the given rates, because the doubled rate gave the highest sugar yield.

Thus, the narrow row space was proved to be better, irrespective of the rates of fertilizer applied.

Effect of multi-line rows

It is not easy to adopt narrow row space, because of its relation to other crops in a farm. To overcome this difficulty, an attempt was made to adopt the multi-line row pattern, in which several rows are closely spaced to make a multi-line row, leaving wide row space for a tread common to other crops. Multi-line rows consisted of 3 or 5 lines, and two levels of row space, corresponding to two kinds of tire width of tractors, were prepared.

As shown in Fig. 3, the multi-line row pattern resulted in lower yield at any row space than the evenly spaced row pattern. However, the highest yield in the multi-line row plots was shown with averaged 50 cm row space, at which the highest yield was also obtained with the evenly spaced row. Yield was always higher with 5 lines than 3 lines, with wider inter-line space than closer inter-line space, and reached to the highest at an averaged row space of 50 cm.

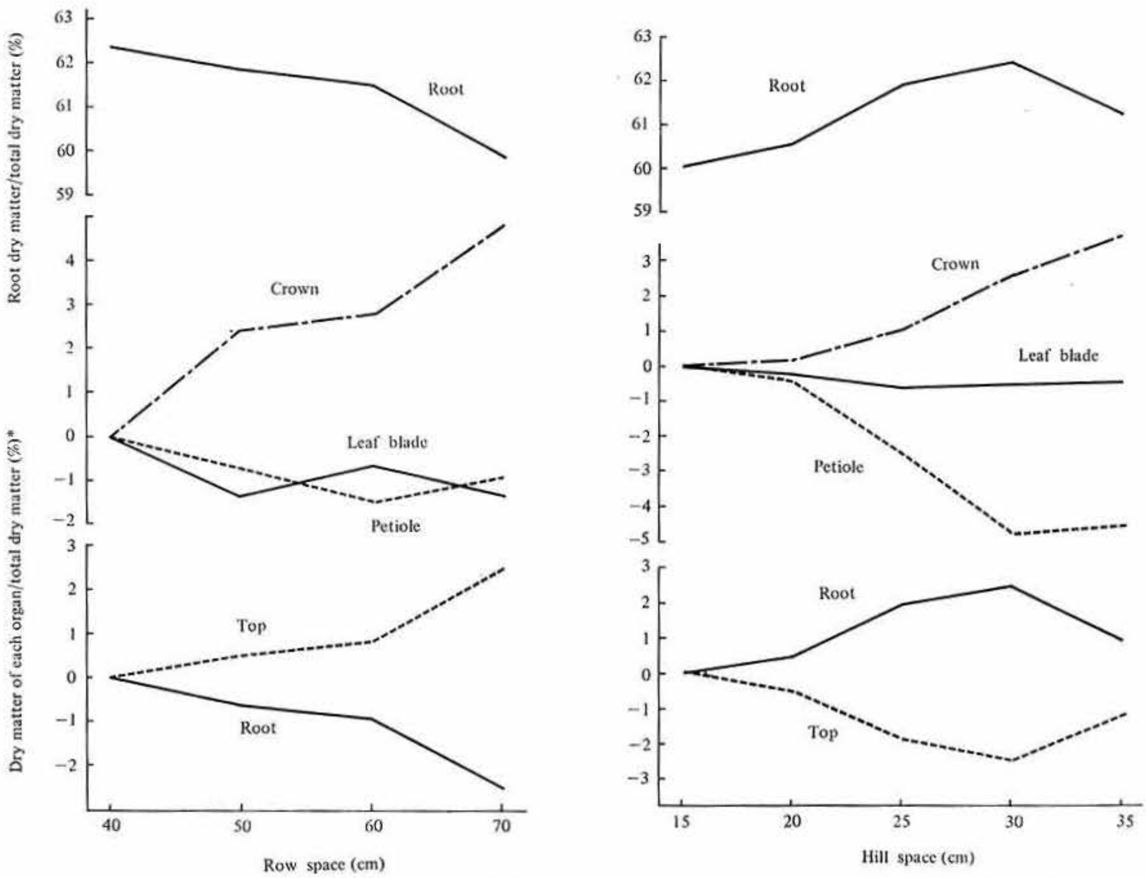

Fig. 4. Distribution of dry matter to different organs as effected by row space and hill space.
Note *: Dry matter in each organ/total dry matter is expressed by changes from that of 40 cm row space of 15 cm hill space.

The multi-line row resulted in low yield due to a reduced land use efficiency as a whole, and an uneven growth of plants caused by close inter-line spacing. However, in this experiment, row space of averaged 50 cm in the multi-line row pattern gave higher yield than the prevalent 60 cm row space in the evenly spaced row pattern, so that it seems to be possible to maintain relatively high yield with the multi-line row pattern, by an appropriate combination of number of lines and inter-line spacing.

Effect of row space and hill space on dry matter production

It was observed in the experiment 2, that dry matter production per land area was greater with closer row space and hill space during an early growth stage, but at the time of harvest there was almost no difference in dry matter with different row and hill spaces. Therefore, it can be said that the distribution of dry matter to roots determines root yields.

As shown in Fig. 4, a proportion of top in the total dry matter was increased with increasing row space. Of the organs of the top, the crown increased remarkably, while leaf blade and petiole tended to decrease, though only slightly. As to the effect of hill space, the increase of crown and decrease of petioles were apparent at 30 and 35 cm hill spaces, but the whole top portion was the least at 30 cm hill space. This result coincides well with the maximum distribution of dry matter to roots observed with 30 cm hill space.

These effects of row and hill spacing on dry matter production are understood on the basis of growth analysis of sugar beet that the differences in root yield caused by varying planting density is determined by the distribution ratio of the total dry matter to roots, reported by one of the present authors[1].

References

1) Izumiyama, Y.: Studies on the production and distribution of dry matter as a basis of sugar beet yield. *Res. Bull. Hokkaido Natl. Agr. Exp. Stn.*, 121, 13–69 (1978) [In Japanese with English summary].

2) Katagi, I. & Izumiyama, Y.: Studies on plant population and distribution of sugar beets cultivation. I. Effects of row width and plant population on root yield and sugar content. *Proc. of Sugar Beet Res. Association*, 17, 201–209 (1975) [In Japanese with English summary].

3) Katagi, I. & Izumiyama, Y.: Studies on plant population and distribution of sugar beets cultivation. II. Effects of row width and intra-row spacing on root yield and sugar content. *Proc. of Sugar Beet Res. Association*, 18, 203–212 (1976) [In Japanese with English summary].

4) Katagi, I. & Izumiyama, Y.: Studies on plant population and distribution of sugar beets cultivation. III. The varietal difference on the effect of row-width and intra-row spacing. *Proc. Sugar Beet Res. Association*, 19, 259–266 (1977) [In Japanese with English summary].