Resistance to Soybean Cyst Nematode by Soybean Variety

By SHIGEO MATSUMOTO

Second Agronomy Division, Tohoku National Agricultural Experiment Station (Kariwano)

Soybean cyst nematode (*Heterodera glycines* ICHINOHE) is one of the greatest bottlenecks in the cultuvation of soybean in volcanic ash soil districts north of the central part of Japan.

The investigation carried out by the Tokachi District Office of Hokkaido in 1958 reveals that the outbreak of soybean cyst nematode (hereinafter referred to as cyst nematode) covered 108,000 ha of 180,000 ha of the same district[2]. And in the Tohoku region the cyst nematode distributes around 50 per cent of soybean cultivated acreage and the living density is so high that the same density has been estimated to be no less than 20 per cent even by limiting to the acreage with large yield decrease[2].

Impact of the soybean cyst nematode on soybean

There are many reports[5),4),8),1)] on the course of invasion by cyst nematode into soybean varieties. Accordingly, the larvae which have hatched from eggs inside the wintered cyst invade the roots of all varieties regardless of resistance and male larvae easily become adults.

Although the female larvae find it difficult to grow over three age inside the roots of resistant varieties and the formation of cyst is difficult, in the roots of susceptible varieties however, the larvae exuviate three times and turn lemon-shape, then easily become cyst and come to contain therein 200 to 300 eggs. The outbreak occurs three times a year in Hokkaido and four times in the Kanto region.

When the cyst nematode parasitizes the roots of soybean, the attaching of root nodule becomes poor inviting nitrogen-nutrient deficiency in the soybean plant. As the result thereof, cyst nematode damage emerges in various characters such as in the stem length, number of branches and stem weight which indicate the nutrient growth and in the number of pods and seed weight which shows reproductive growth. Close relation has been recognized between the change conditions of those various characters under the parasitism of cyst nematode and seeds-weight-yields-decrease rate.

1) Change in flowering and maturing periods under parasitism of cyst nematode

Cyst nematode parasitism tends to quicken the flowering period by about one to two days.

The maturing period varies from those which are hastened by one to two days to those which are delayed from several days to around 10 days. In general, early varieties quicken a little and the change is small in medium varieties. Late varieties manifest a certain kind of 'Aodachi'* symptom and as the result the maturing period usually is delayed. Those changes have no relation[3)] to the resistance of varieties.

2) Seeds weight in cyst nematode field

The yield decrease rate in seed weight per stump of the cyst nematode field against ordinary field is taken as an important standard to classify the strength of varietal resistance. The yield decrease rate is computed under the following formula:

* Remains immature stand

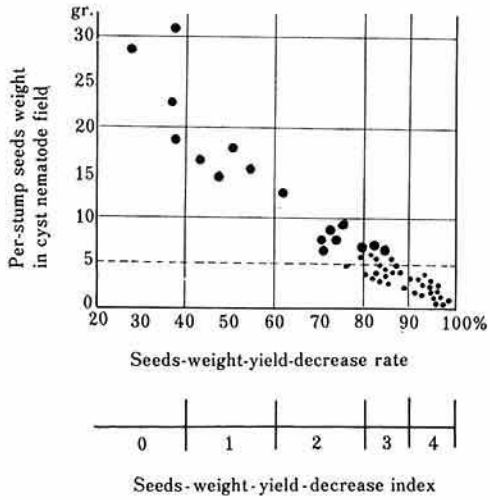

Fig. 1. Relation between seeds-weight-yield-decrease rate and seeds weight per stump (crude grain weight) in cyst nematode field

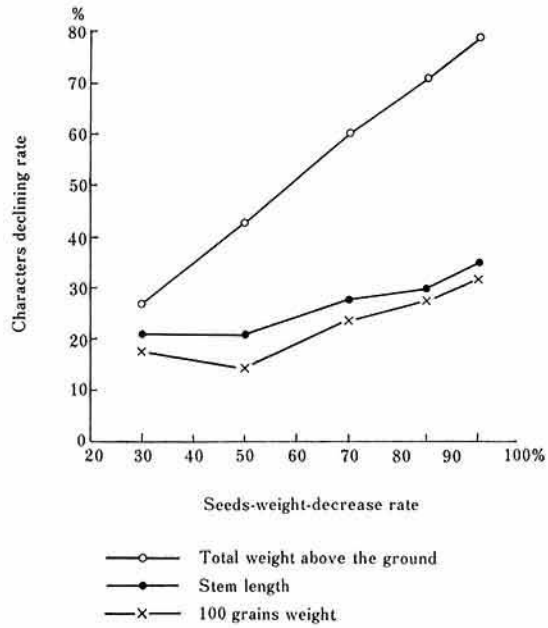

Fig. 2. Relation between seeds-weight-yield-decrease rate and decline rate of 2, 3 characters

$$\text{Yield-decrease rate}=\frac{\text{Wt. in ordinary field}-\text{Wt. in cyst nematode field}}{\text{Wt. in ordinary field}}\times 100$$

As shown in Fig. 1 a very high negative correlation[3] can be witnessed in the seeds-weight-yield-decrease rate and seeds weight per stump of the cyst nematode field. Accordingly, regardless of the difference in the amount of the original productive power of variety the variation in seeds weight in the cyst nematode field is recognized as the direct manifestation of the strength of resistance.

3) Decline rate of stem length by the parasitism of cyst nematode

The decline rate of stem length during the maturing period (computed under the same formula for yield-decrease rate) differs by early and late maturing characters of variety and by the resistance to cyst nematode and the rate ranges from the minimum of 2 per cent to the maximum of 46 per cent.

The decline rate of stem length of early variety is very small in comparison to medium and late varieties. In medium and late varieties the amount of seeds-weight-yield-decrease rate and the decline rate of stem length are comparatively well correlated. (Fig. 2)

4) Degree of damage during growth under the parasitism of cyst nematode

The above-the-ground conditions of soybean varieties in the cyst nematode field (mainly the degree of the yellowing of leaves and the magnitude of growth) have been observed after classifying the damage degree into five grades (non, small, medium, large and very large) and 0, 1, 2, 3 and 4 have been allotted respectively to each grade as the damage index.

The investigation has been carried out three times before and after the period when the damage during growth has reached the peak from the overall standpoint (August 25) and by studying the relation between the damage index during growth and the seeds-weight-yield-decrease rate of variety by integrating the investigation results comparatively a good

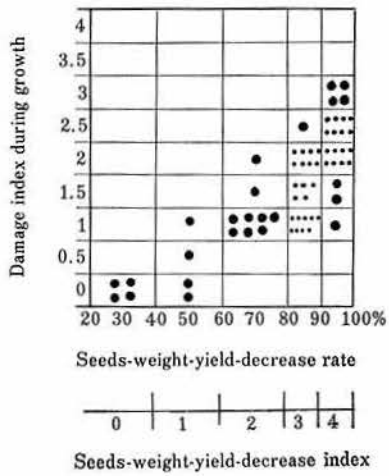

Fig. 3. Relation between the damage degree during growth in cyst nematode field and seeds-weight-yield-decrease rate

correlation[2] can be witnessed as shown hereunder.

Accordingly, even by the method of naked eye observation of damage degree during growth in the cyst nematode field, it is safe to assume that the strength of resistance of variety can be judged on the whole.

5) Degree of decline in the above-the-ground-total-weight by the parasitism of cyst nematode

The decline degree of the above-the-ground total weight per stump by the parasitism of cyst nematode is lighter than the yield-decrease-degree of seeds weight, the decline rate ranging from 22 per cent to 90 per cent.

However, the seeds-weight-yield-decrease rate and the decline rate of the above-the-ground-total-weight show a positive correlation[3] (Fig. 2), particularly a very high correlation with the early and medium varieties except the late one.

The growth of stems and leaves of late varieties grown in the cyst nematode field is comparatively large. However, upon finally nearing the maturing period there is practically no bearing of pod, manifesting in most cases, a broom-shaped 'Aodachi' condition.

6) Decline degree of 100 complete grains weight by the parasitism of cyst nematode

The weight of 100 complete grains in the cyst nematode field declines from 10 per cent to as much as 40 per cent in comparison with ordinary field. In the case of individual variety, it can generally be said that the larger the seeds-weight-yield-decrease rate, the larger the decline rate of 100 grains weight, and the smaller the seeds-weight-yield-decrease rate, the smaller the change of 100 grains weight[3] (Fig. 2).

7) The amount of parasitic cyst nematode in cyst nematode field and the amount of root nodule attached to roots

Practically all varieties of strong resistance to cyst nematode are small in the infestation of cyst nematode with no exception but the varieties of weak resistance vary greatly from large to small amounts in cyst nematode parasitism.

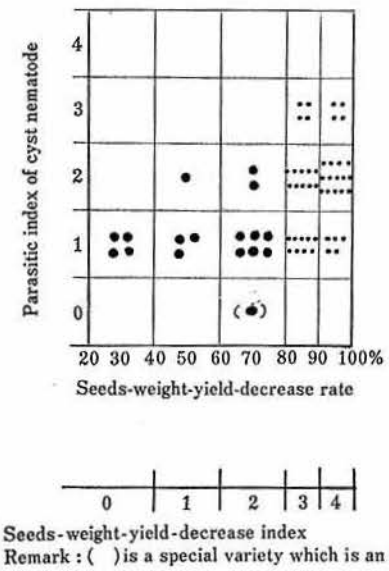

Fig. 4. Relation between the cyst nematode paratisism and seeds-weight-yield-decrease rate

As a whole, the cyst nematode parasitic index and the seeds-weight-yield-decrease rate indicate a positive correlation[3] although not

to the extent of strong degree as shown hereunder.

The relation between the amount of root nodule attached to the root and seeds-weight-yield-decrease rate has a little stronger negative correlation[3] than the relation between the cyst nematode parasitic index and the seeds-weight-yield-decrease rate. (See Fig. 5)

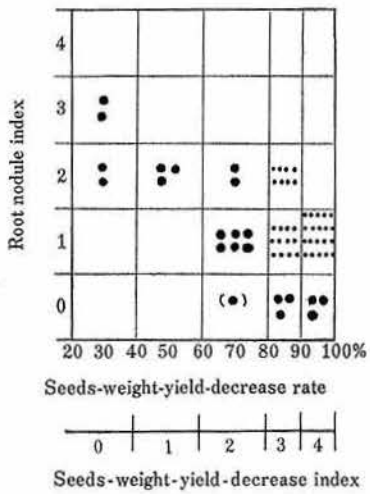

Fig. 5. Relation between the amount of root nodule attached to root and seeds-weight-yield-decrease rate

Assaying method of soybean cyst nematode resistance

1) Method by the seeds-weight-yield-decrease rate

Because of the fact that in many cases the living density of cyst nematode in soil differs even in closely neighboring habitats, so the assaying of intrinsic resistance of variety is difficult. So in the cyst nematode field continuous croppings of weak resistance varieties are carried out promoting the cyst nematode density and the distribution of nematode is uniformalized by such artificial measure as transferring the top soil of a highly damaged area to a light damaged area.

A control field without damage from cyst nematode is a field with practically no infestation of cyst nematode by crop rotation and is selected near the assaying field.

The seeds weight from both fields are measured and assaying is made by comparing yield decrease rate computed under the formula stated above with several standard varieties. (Very strong, Peking; strong, Nemashirazu; medium, Yogetsu No. 1 and weak, Ibaraki-mame No. 7)

2) Method by characters during growth

Resistance can be detected approximately under the method of judging the damage degree by observing the degree of leaf-yellowing, the amount of the vegetation, the number of beared pods and the height variation of the location of beared pods.

3) Method by the amount of cyst nematode parasitizing the root of young seedling

A root is dug up 45 days after germination and the strength of resistance is judged by the amount of cyst nematode attached. Afterward upon replanting in pot it is possible to harvest seeds. The assaying inside a greenhouse is advantageous in that it is possible to conduct the assaying in winter (Plate 1) and is easier to isolate the cyst nematode infested soil from ordinary field.

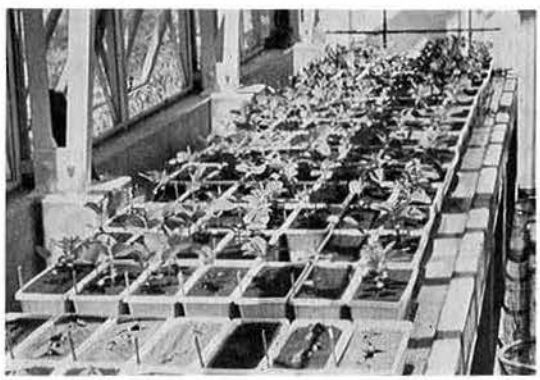

Plate 1. Young seedling assaying material inside the greenhouse

4) Method by the number of cyst nematode parasitism on the root of mature plant

The early generation hybrid to be tested is transplanted on cyst nematode uniformed field under single stem training with 60 cm row

width and 10 cm spacing and the above-the-ground part is observed during mid-vegetative stage and those which have been recognized as damaged are pulled out.

As for those plants which are recognized as free from damage the strength of resistance is determined by observing the number of infestation by digging up half of the root.[6]. This method makes possible a definite asssaying of resistance the same as 3); moreover, it is advantageous in that its seed can be harvested.

Breeding of resistant varieties

There are two kinds of cyst nematode distributed in Japan—Kikyogahara strain subsisting in the soil near Shiojiri-city, Nagano Prefecture, and Kariwano strain in the soil of Tohoku region and Hokkaido. The former's parasitism is stronger than the latter's with a stronger damage. The Peking type varieties[7] which have the strongest resistance to the former and the same type varieties and the Gedenshirazu[7] type which is a little weaker than the former are being used as breeding mother plants.

The cyst nematode resistant varieties bred so far are Horai and Toyosuzu at the Tokachi Agricultural Experiment Station and Nema-Shirazu, Raiden, Raiko, Okushirome and Karumai at the Tohoku National Agricultural Experiment Station and Nasushirome at the Nagano Prefectural Agricultural Experiment Station.

References

1) Endo, B. Y.: Histological responses of resistance and susceptible soybean varieties and backcross progeny to entry and development of *Heterodera glycines*. *Phytopathology*, 55, 375–381 (1965).
2) Fukui, J.: Breeding of soybean. Latis, Tokyo (1968).
3) Ishikawa, M. Miyahara, T.: Reaction of soybean varieties to the soybean nematode (*Heterodera glycines*). *Japan J. Breed.*, 8(2), 111–118 (1958) [In Japanese].
4) Ichinohe, M.: Studies on the soybean cyst nematode, *Heterodera glycines*. *Hokkaido Nat. Agr. Exp. Sta. Report*, 56, 88 (1961).
5) Ross, J. P.: Host-parasite relationship of the soybean cyst nematode in resistant soybean roots. *Phytopathology*, 48, 578–579 (1958).
6) Saito M., Sunada, K. & Sakai M.: Breeding of soybean cyst nematode resistant varieties in Hokkaido. *Agriculture and Horticulture*, 48(10), 1337–1342 (1973).
7) Sugiyama, S. & Hiroma, K.: Studies on the resistance of soybean varieties to the soybean cyst nematode. I. Comparison of varietal responses. *Japan J. Breed.*, 18(2), 80–87 (1968) [In Japanese].
8) Yuhara, I. & Inagaki, H.: Studies on the resistance of soybean plants to the soybean cyst nematode, *Heterodera glycines*. II. Relations between the development of larvae invaded in the roots and the resistance of soybean varieties. *Bull. Hokkaido Nat. Agr. Exp. Sta.*, 80, 94–102 (1963) [In Japanese].