OKAZAKI, KAZUYUKI*, HIROYUKI TAKAHASHI, KAZUNORI TAGUCHI, YOUSUKE KURODA and HIDEYUKI ABE, National Agricultural Research Organization, Shinsei Memuro, Hokkaido 082-0071, Japan. **Evaluation of sugar beet lines bred in Japan to examine resistance to damping-off caused by *Aphanomyces cochlioides***

ABSTRACT

Damping-off, which is caused by *Aphanomyces cochlioides* Dreschsler, is known to be one of the major factors responsible for a poor stand of sugar beet. In the case of direct sowing culture, damping-off results in a lack of harvestable plants and severe loss of yield; therefore, the occurrence of this disease is a major problem. On the other hand, in the case of transplanting culture, this disease does not pose as large a problem because only healthy seedlings are selected and planted in the field. In Hokkaido prefecture in Japan, the major style of cultivation that is practiced is transplanting culture (in 2000, 97% of the cultivation was based on transplanting culture). However, in recent years, the direct sowing culture has been reevaluated as a low-cost cultivation practice. In 2007, cultivation based on direct sowing culture reached 7.4%, and it is expected to increase with time. Therefore, it is necessary to investigate which measures should be adopted to prevent damping-off. Outside Japan, numerous studies have been conducted on this disease. It is well known that the resistance to *Aphanomyces* damping-off differs among lines, and it has been reported that some lines show considerable resistance. The following are the objectives of this study: (1) evaluate sugar beet lines bred at the National Agricultural Research Organization (NARO) in Japan against damping-off caused by *Aphanomyces* and (2) clarify the inheritance of this resistance trait by performing half-diallel analysis.

Evaluation tests were conducted in a greenhouse (16 h daytime-25°C, 8 h nighttime-20°C). We used 100 breeding lines for this study (including 12 pollinator lines and 88 O-type lines). Of each line, 108 seeds (3 replicates of 36 seeds) were sown into a pot containing 250 g sterilized field soil with peat moss (diameter, 8 cm; depth, 10 cm). Two weeks after sowing, the seedlings were inoculated with zoospore suspension (12,500 zoospores in each pot). Four to five weeks after sowing, each seedling was classified according to the severity of the disease into the 6 following stages: 0 (no symptoms); 1 (clear symptoms); 2 (light); 3 (intermediate); 4 (severe); and 5 (dead). The disease index (DI) of each line was calculated as the average of the 3 replicates. To compensate for inter-experimental variation, the F1 cultivar of standard sugar beet "Monohomare" was included in each test.

The result of the evaluation tests showed that there were significant differences among the breeding lines with respect to the DI. The DI of the standard cultivar "Monohomare" was considered as the reference. The O-type lines exhibited varying degrees of resistance, and 11

lines were found to be resistant. The DIs of all the lines derived from TK-76 were significantly low as compared to those of the “Monohomare” cultivar, and the former were thus classified as resistant lines. This result suggests that TK-76 had gene(s) conferring resistance to the damping-off disease. In contrast, all the pollinator lines were found to be susceptible to the disease. From this result, we conclude that it is essential to improve the resistance of the pollinator lines in order to develop a resistant F1 cultivar.

A set of half-diallel crosses was made involving 5 O-type lines as parents. The F1 generations and 5 parents were evaluated for their resistance in a similar fashion as described above. We also included NK-333mm-O (resistant), Monohomare (moderately resistant), and Cultivar A (susceptible) in the same test as standard cultivars. Genetic analysis was carried out by the program “DIALL” developed by Ukai (1989).

Among the tested parents, NK-237BRmm-O (DI = 2.0) had the lowest DI, which was almost the same as that of the resistant line NK-333mm-O (DI = 1.7). NK-195mm-O (DI = 4.2) had the highest DI, which was almost the same as that of the susceptible Cultivar A (DI = 4.1). The DIs of all the F1 progeny ranged from NK-237BRmm-O to NK-195mm-O. The results of analysis of variance, which was conducted according to Jones’s formula (1965), indicated significant additive and dominant genetic effects. Among the dominant effect, b1 (refers to general dominance) was not significant but b2 (refers to further dominance due to a particular parent) was significant. The DIs of the F1 progeny that had NK-229BRmm-O or NK-185BRmm-O as parents closely resembled the DI of NK-229BRmm-O or NK-185BRmm-O, respectively. Therefore, we inferred that NK-229BRmm-O and NK-185BRmm-O are the factors that confer significant dominance to b2. The graphical analysis of Wr/Vr revealed that epistasis was not detected, and clarified that the additive-dominance model fitted to the disease resistance. NK-229BRmm-O had the most dominant genes; however, the DI of this line was 3.9, and it was classified as susceptible one. On the other hand, the resistant line NK-237BRmm-O had the most recessive genes. Moreover, none of the NK-237BRmm-O F1 progeny was classified as resistant. Therefore, in order to breed resistant F1 cultivar, both parent lines should be resistant. The average degree of dominance was 0.947, and the disease resistance was a completely dominant trait. The heritability values considered in the broad sense and narrow sense were 0.906 and 0.629, respectively. This result indicates that the resistance to damping-off may improve efficiently. Moreover, in order to increase the resistance of a line to the damping-off effect, it may be useful to select for genes with the additive effect that control disease resistance.