EFFECTS OF INTEGRATED CONTROLS AGAINST CERCOSPORA LEAF SPOT IN SUGAR BEET

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The damages of the fungus *Cercospora beticola* Sacc. to sugar beet crop are firstly due to a reduction of leaf area. Secondly, under severe disease, the plant reacts with an abnormal development of new leaves, also called regrowth (Borrelli *et al.*, 1990). To reduce the effects of cercospora leaf spot (CLS), resistant varieties can be used. This strategy must be combined with the use of fungicides, applied from the first appearance of symptoms on the leaves (Smith and Campbell, 1996).

The efficacy of genetic resistance or chemical treatments is partial and the combination of both is necessary, though not sufficient to eliminate the yield losses caused by the disease. The limitation of costs and environmental effects of fungicides require for the future a significant increase of genetic resistance, but the results in this direction are still limited (Shane and Teng, 1992; Campbell and Smith, 1995; Skaracis and Biancardi, 1999).

Many studies have been published on the epidemiology and the primary effects of the disease (Pfeiderer and Schäufele, 1996), but very little is known about the physiology of regrowth and the associated sucrose losses (Shane and Teng, 1992).

A controversial issue is the assessment of the resistance on the basis of visual evaluation of the infection on the leaves. When resistance is established in this way, the best-scoring hybrids often are the least productive. This makes the choice of varieties quite difficult for the farmers (Miller *et al.*, 1994; Smith and Campbell, 1996).

In Italy, CLS epidemic is widespread and causes significant losses especially in the Po valley. Field tests were planned with the aim to understand better the relations among resistance, production traits and integrated management of the disease. In this paper the most interesting and preliminary results are shown.

Materials and methods

In 1997, a set of 40 varieties used in Italy was grown in 3 field tests located near Mantova, Ferrara and Ravenna (trials A). Each plot was divided in 2 parts, only one of which receiving the fungicide protection. Care was taken to keep the sub-plots separated enough to avoid the fungicide spreading into the untreated half. Each trial involved 6 replications. The sprays against CLS were started near the end of June, when the early foliar lesions became apparent. They were repeated every 20 days as in the commercial crop. Each trial received 3 or 4 treatments with Alto BS® at 2 kg of formulated product per hectare. One harvest was made in the second half of September. The trials were repeated in 1998 with the same experimental protocol. In the last tests 42 varieties were used, 34 of which were already employed previously.

A new set of trials was planned in 1998 aimed to increase the effects of both treatments and harvest times (trials B). The 6 tested varieties were chosen on the basis of very different CLS resistance, good productive levels and high rhizomania resistance. This last trait was necessary to avoid interferences from BNYVV, if variable in the fields or present in amounts not detectable by ELISA.

The 3 tests, carried out in Rovigo, Ferrara and Ravenna districts, involved 4 replications. The plots with 3 levels of protection (untreated control, normal treatment and double treatment) were large enough to allow 3 samplings each in different periods of the campaign. The first 2 levels were performed as above mentioned; in the case of the latter, the time elapsed between 2 treatments was about 10 days. As a consequence, a total of 8 sprays were made, instead of 4 on the normally protected sub-plots. The fungicide used was the same as in the trials A, at the same dosage.

During the trials A and B, at least 2 visual scorings of the CLS symptoms were made. Scores were estimated with special diagrams (Shane and Teng, 1992) evaluating the percent of diseased leaf area (0=no symptoms; 100=complete defoliation). At mid-September, evaluations were also made on the varieties regrowth rates of the plants in trials B. The following scale was used: 0=no regrowth; 3=strong regrowth.

Results and discussion

Figure 1 shows the production levels of the 34 varieties tested over 2 years with and without the normal fungicide treatments (trials A). It can be observed that the Z-type varieties, at the top left of the diagram, show a lower sucrose production compared with the E-type (bottom right in the figure). This holds true for both treated and untreated plots. Some resistant (R) varieties (i.e. those with the best rating given by visual observations) perform worse than some susceptible (S) ones even on untreated plots too. The production increase due to fungicide treatments is generally higher on Z-type varieties. It is also observed that some hybrids in the absence of any fungicide protection produce better than others do after 3 treatments. The resistance, as established according to the leaf infection, is not always correlated with the sucrose production especially in presence of low epidemics. This trend indicates the limited practical utility of such evaluations.

The growers in areas regularly infected by cercospora should choose varieties that are able to perform well even without fungicides. Generally, the most interesting materials are the very productive hybrids endowed with a low to moderate levels of resistance. If there is the necessity of chemical sprays, the gain in sugar yield of such hybrids is satisfactory. To meet the grower's needs, it is necessary to find an index more directly correlated with the money return. It would be important to relate to untreated tests, including the most widely cultivated varieties for that particular area. Considering the average sucrose production as 100, the best varieties under CLS attack will have indexes exceeding 100. To have a reliable score, it is however necessary to carry out some trials in different locations and years, possibly including the same set of varieties. Besides, it is important during the tests to have the infection pressure on the plots strong and homogeneous, making also use, if necessary, of artificial inoculation.

Considering the trials B, Figure 2 shows that the productive reduction caused by CLS is proportional to the intensity of the disease, which were higher in Rovigo than Ferrara and Ravenna. The reduction is given by the difference between the data relative to the double-treated and the untreated plots, i.e. between the situation of minimal and maximal infection. Because even the double-treated plots are not completely free from CLS, the zero-infection point is located rightward. Therefore, the disease-caused sucrose loss is larger than can be estimated from the figures.

Figure 3 shows the effects of the harvest times. Also in this case it is clear that the efficacy of the integrated controls improves with the increasing infection during the season. The difference between the double-treated and the untreated plots is about 2 t/ha of sugar in the first harvest and exceeds 3 t/ha in the third harvest. The 3 degrees of protection induce on the plots different levels of infection: maximal in the untreated and minimal in the double-treated one. Considering the first harvest, it can be observed that going from a low to an intermediate infection (i.e. from double to normal treatment) the productive reduction mainly involves the root weight; from the intermediate to the maximal infection (i.e. from normal to untreated plots) the decrease is mainly due to a lowering of polarimetric degree (Shane and Teng, 1992). The first harvests were done in the second half of August, when the regrowth was occurring in the untreated plots only; whereas on the treated ones the infection was evident only as the typical foliar symptoms. It is likely that the plant reaction to the infection (a weight loss before and a polarimetric degree lowering thereafter) corresponds to 2 different actions of the disease: before on the leaf-assimilating surface and after on the regrowth. In the later harvest times, regrowth involves increasingly the protected plots as well.

The processing quality (Figure 4) varies as a function of the treatments and the harvest periods. The trend is very similar to the polarimetric degree shown in Figure 3. With the increase of the infection (from the double treated to the normally treated plots), the quality remains constant and then declines quickly. This trend is particularly evident in the first harvest. Probably the metabolic alterations associated to the regrowth are the bases of the worsening of the quality. Among the analyzed impurities, sodium reacts more directly to the increasing infection, as pointed out by Schäufele and Wewers, 1996.

In Figure 5, the 2 most sensitive varieties among the 6 were separated from the 2 most resistant ones. These latter are both E-type with a moderate CLS resistance. However, it should be specified that the differences between the 2 pairs could be due, at least in part, to factors differing from their reaction toward CLS. The protective effects of resistance and treatments in the first harvest time have nearly the same magnitude (about 1 t/ha of sugar), and increase up to about 2 t/ha in the third harvest. Here, the reduction in the damage, through standard chemical treatments integrated with resistant varieties now available, is about 4 t/ha. With the introduction of more frequent sprays (as was done in the double treated plots) or of more effective fungicides or of higher levels of genetic resistance, a further gain of about 2 t/ha of sugar could be reached. In the last harvest, when CLS epidemic is heaviest, the total losses without integrated management would exceed 40% of the theoretical sugar production attainable in the absence or with a complete control of the disease. The score given to the regrowth rates in the trials B resulted directly correlated to the increased genetic resistance of the varieties. This positive and significant correlation, which appears to be quite surprising, will be verified in the current year.

Conclusions

Knowledge of the mechanisms through which some genotypes can limit the effects of CLS is still poor. As a consequence, a substantial improvement of the resistance is presently difficult. Nevertheless some new E-type varieties appear to be endowed with both moderate-high levels of resistance and very good sugar yield under diseased and healthy conditions.

The evaluation of the infection on the canopy often does not correspond to the production traits. Taking in account the current or future environmental restrictions on the use of pesticides, it appears to be more reliable to evaluate directly the variety production ability under severe disease conditions and without any chemical protection. If harvested late in the season, the trials should be able to assess also the damages caused by regrowth, if present. The best performing hybrids in such conditions need reduced fungicide sprays for producing equal amounts of sugar. They can be chosen with the aim, among other things, of a more ecologically sound cultivation. The tendency to regrowth, shown to be positively correlated to the resistance degree, should be carefully avoided because of its effects on both sugar yield and processing quality.

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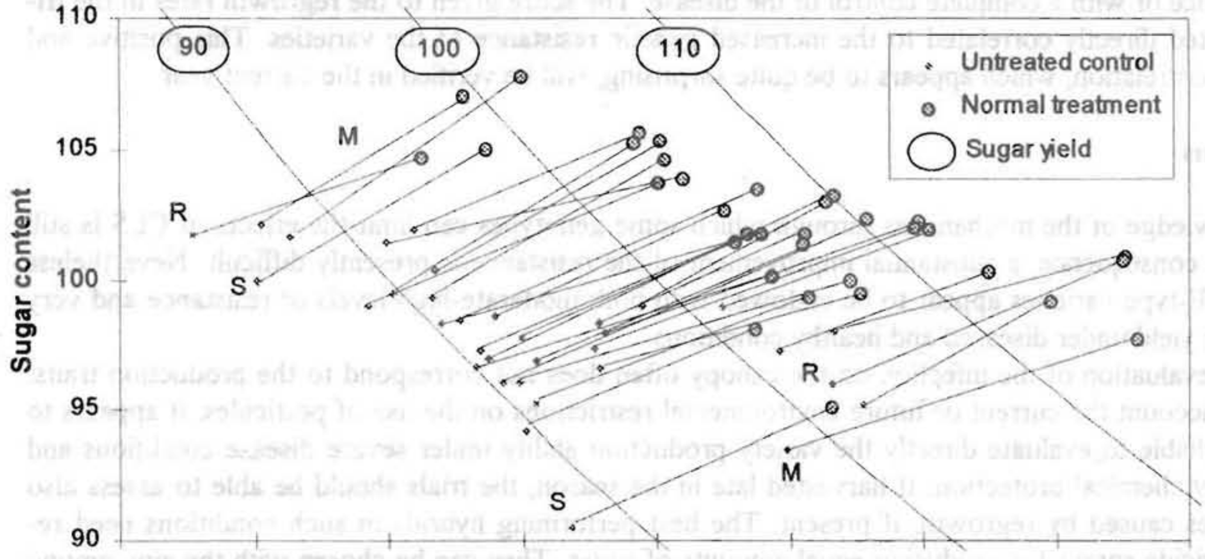

Fig. 1 - Effects of normal fungicide protection on 34 commercial varieties (S = susceptible; M = moderately resistant; R = resistant variety).

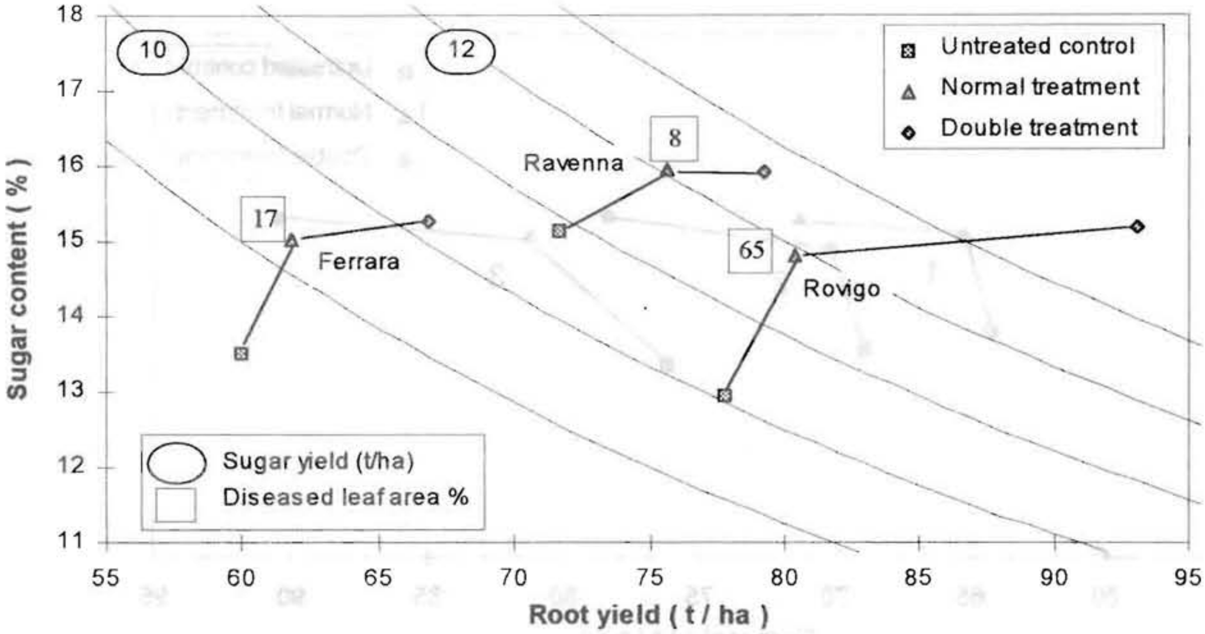

Fig. 2 - Effects of 3 levels of fungicide protection on the mean production of 6 varieties in 3 localities with moderate-severe CLS epidemics.

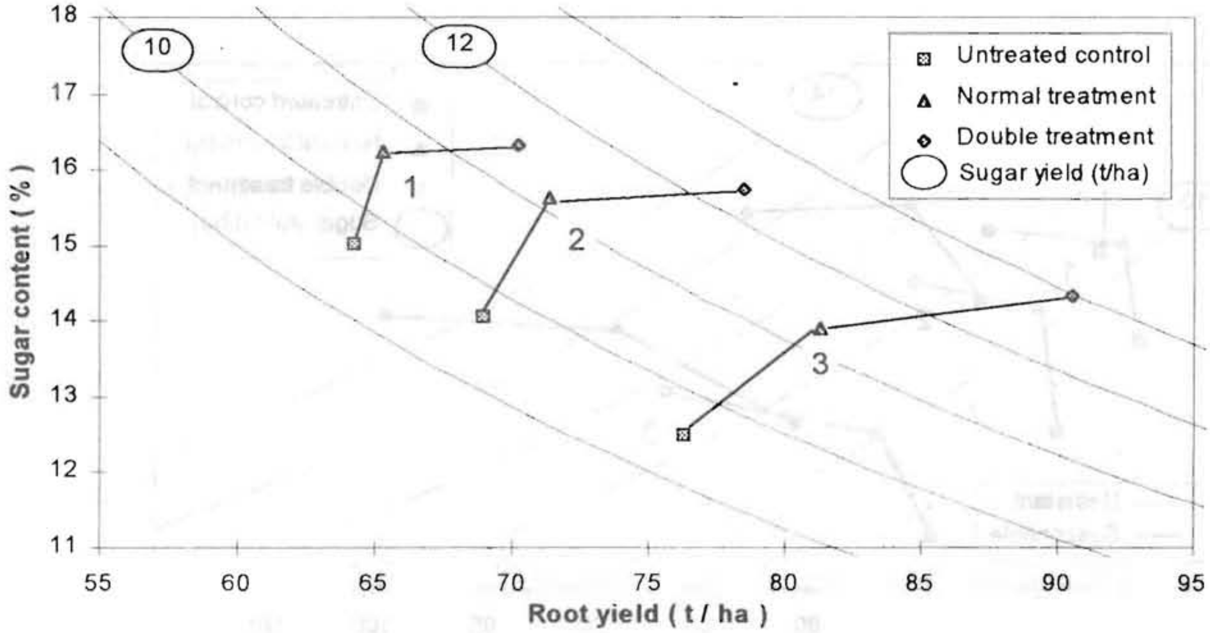

Fig. 3 - Effects of 3 harvest times and 3 levels of fungicide protection on the mean production of 6 varieties.

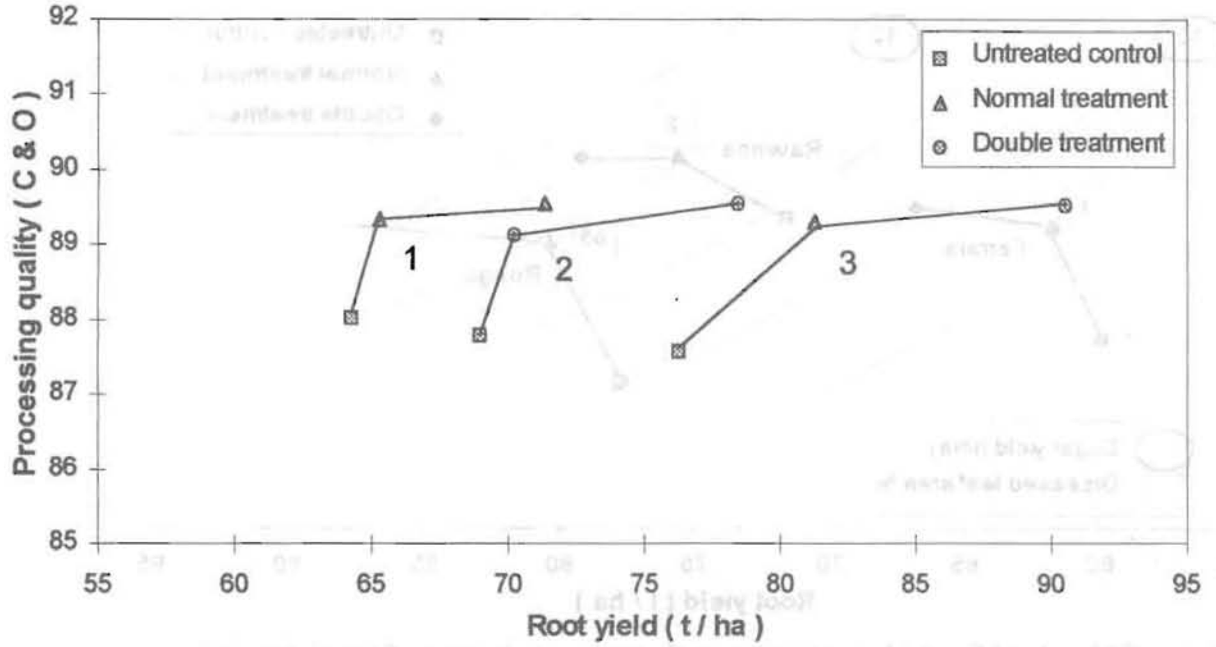

Fig. 4 - Effects of 3 harvest times and 3 levels of fungicide protection on the processing quality of 6 varieties. The last trait was calculated according to Carruthers and Oldfield, 1961.

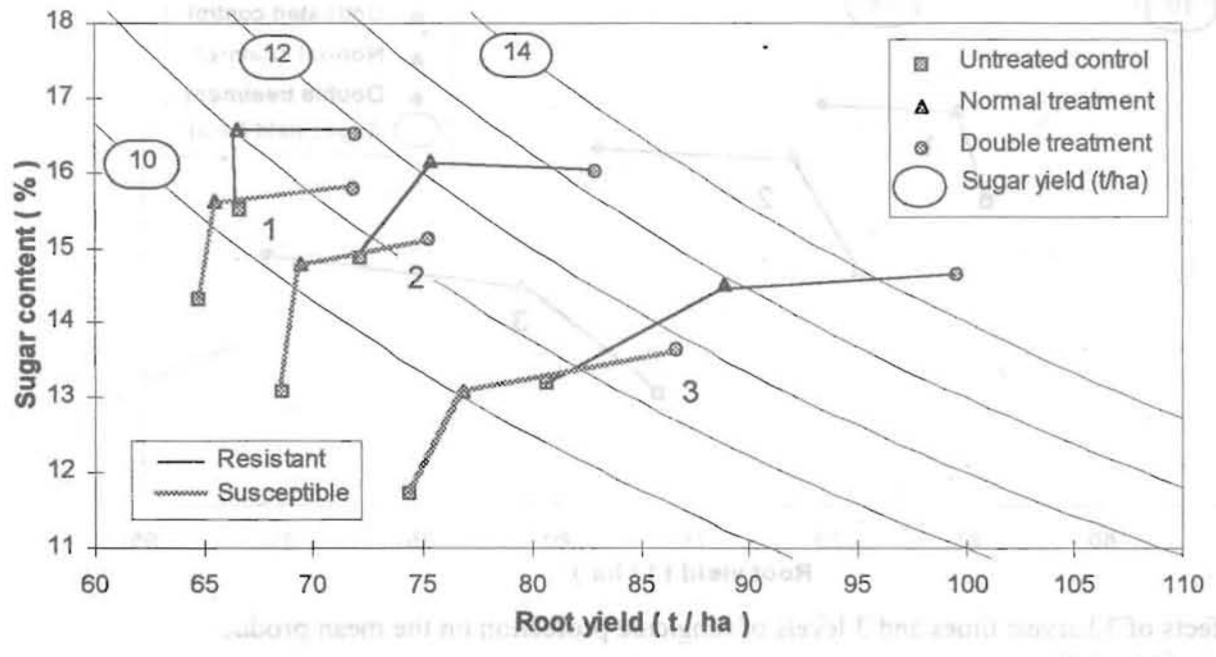

Fig. 5 - Effects of 3 harvest times on the production of 2 resistant and 2 suceptible varieties.