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Studies of the tolerance of maize hybrids to corn rootworm in Hungary

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Abstract

The appearance of corn rootworm is one of the greatest plant protection challenges that European maize production has faced in its 500-year history. Since the first specimens were caught in 1992, the pest has now spread to all the major maize-growing areas in the Carpathian Basin. Control of the pest is complicated by the fact that farmers often ignore the need for crop rotation, the most effective measure, despite ministry regulations. Chemical control not only increases production costs, but is not always effective. The present paper describes studies on the tolerance level of 43 Martonvásár hybrids at three locations in two years. Significant differences were found in the tolerance levels of the hybrids, and a close positive correlation was revealed between root-pull resistance and yield, while there was a close negative correlation between root lodging and yield and between root-pull resistance and lodging. Root regeneration is also an important factor, good values of which were found for three hybrids.

Key words: Western corn rootworm, tolerance level, resistance breeding

Introduction

Maize production is one of the most important sectors of agriculture in Hungary. On the basis of profitability it has been one of the top-ranking field crops in recent years, and is grown on an area of around 1.1-1.2 hectares. Until recently, apart from a few pathogens, it has suffered little damage from pests, but this situation changed after the appearance of the corn rootworm in 1995, which became a major maize pest within a few years (RIPKA 2007). It is estimated that around 100,000 ha were affected on a third of which lodging has been recorded. No accurate data are available on the yield losses suffered in Hungary, but they probably amount to around 5% on a national scale.. The yield losses caused by the pest may range from only a few per cent to as much as 70-80% (SIVCEV and TOMASEV 2002, NAGY et al. 2003). American data indicate that yield losses combined with the cost of control lead to a loss of income amounting to around a billion dollars a year (KRYSAN and MILLER 1986). Insect numbers and the extent of damage are greatly influenced by the weather in the given year (KESZTHELYI 2006).

In addition to agronomic, chemical and biotechnological control measures, work has been underway for several decades to breed maize varieties resistant to the pest (BIGGER et al. 1941, OWENS et al. 1974, ABEL et al. 2000, PEPÓ and BÓDI 2006, IVEZIC et al. 2006). Among the three basic mechanisms of host-plant resistance (non-preference, antibiosis, tolerance) defined by PAINTER (1951), conventional plant breeding can only be based on tolerance, where differences arise mainly as the result of diverse growth habits (stronger stalks, more robust root mass, better root regeneration). According to SEITZ (2006) a combination of molecular markers and the DH technology could open up new possibilities in breeding against the pest. The present paper aimed to determine the corn rootworm tolerance levels of sixty maize hybrids.

Materials and methods

In order to determine the level of tolerance against corn rootworm, 43 Martonvásár maize hybrids were sown in experiments at three locations with three replications in 2007 and 2008. All parental inbred lines of the 43 hybrids were also evaluated in 2008. The extent of natural rootworm infection in the previous year and the type of soil were taken into consideration when choosing the locations, which included heavily infested chernozem soils only. The two-rowed plots were 6 m in length with row and plant spacings of 0.7 m and 0.2 m, respectively. At each location the root-pull resistance was recorded on two occasions (end of June, middle of Sept.) on 5 plants per plot for each genotype, after which the visible root damage was scored using the Iowa scale (1: no damage, 6: loss of three or more root levels) and the root diameter was measured. The latter values were used to determine the extent of root regeneration (by subtracting the June values from the September values). After counting the number of lodged plants the yield was harvested from a 2 m section of each plot. The data were evaluated using analysis of variance and regression analysis.

Results and discussion

Different levels of root damage were recorded for the tested hybrids at the three locations and in the two years. The infestation was most severe in Kőszárhegy in 2007, followed by Lászlópuszta, with the least damage in Martonvásár. A higher level of infestation was expected based on the corn rootworm damage in the previous year. The infestation was most severe in in Martonvásár in 2008, followed by Lászlópuszta, with the least damage in Martonvásár. Differences in the degree of infestation were also observed between the two scoring dates for root damage in 2007. At the second scoring date there was a substantial reduction in damage compared

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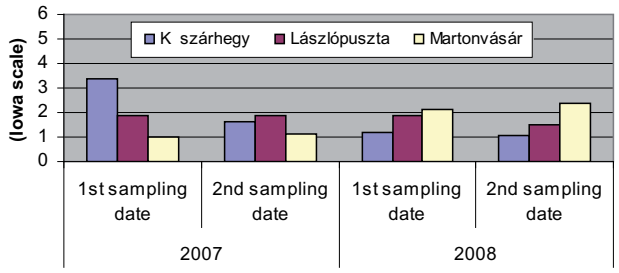

Figure 1: **Root injury in different locations, averages of hybrids (2007-2008)**

with the first scoring date in Kőszárhegy, mainly due to root regeneration (*Figure 1*), which could be attributed partly to timely rainfall and partly to genetic differences in regeneration between the hybrids. There was no significant differences between the two sampling date in 2008.

The 43 genotypes tested had different levels of tolerance of the pest, as shown by the considerable differences in root-pull resistance (72-126 kp) and in the values on the Iowa scale (1.2-2.4) (*Figure 2*). Hybrids with greater root-pull resistance values exhibited significantly less root damage than those with weaker resistance.

In 2008, the resistance levels of both the hybrids and their parent lines were investigated in all three locations. The degrees of root infection demonstrates that corn rootworm damaged the inbred lines 20% more severely than hybrids according to Iowa scale (*Figure 3*).

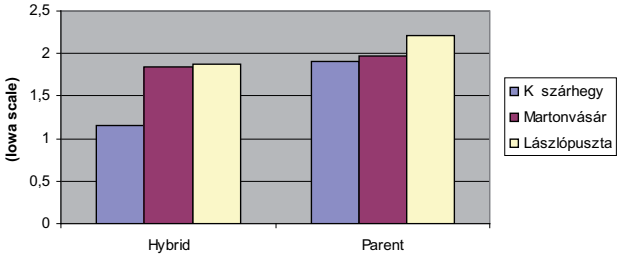

Figure 3: **Root injury of the hybrids and lines in different locations (First sample, 2008)**

Inbred lines have smaller root diameter (*Figure 4*) and lower root pull resistance than hybrids (*Figure 5*). The heterosis on root diameter, compared to the average of parents is 140%, while in case of root pull resistance the heterosis is 123%. However, significant variation can be observed in the root pull resistance of inbred lines. The root pull resistance was 37 kp for the inbred lines with the weakest resistance, and 129 kp for the strongest ones, requiring 3 times larger force to be pulled out from the soil. The low level of heterosis

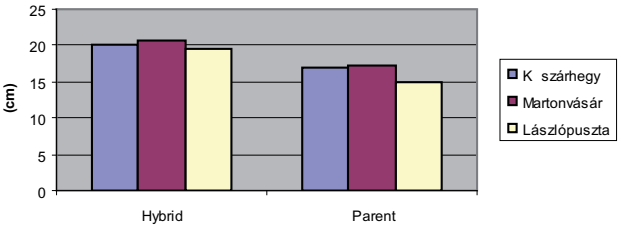

Figure 4: **Root size of the hybrids and lines in different locations (First sample, 2008)**

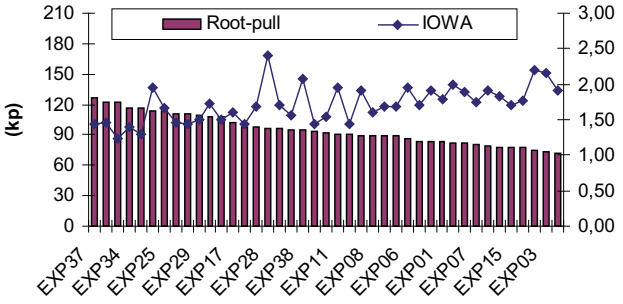

Figure 2: **Root-pull and root injury of the hybrids (average of 3 locations, 2 years and 2 samples)**

and the wide range of variation enable efficient selection during inbreeding.

Conclusions

The 43 maize hybrids tested were found to have different levels of tolerance against the corn rootworm. Tolerance is based mainly on external traits such as a stronger root system

with better regeneration ability. Some hybrids had outstanding root regeneration ability. The selection method used in the experiments, based on root-pull resistance measurements combined with the counting of lodged plants and the scoring of root damage on the Iowa scale, proved to be suitable for the relatively rapid testing of the tolerance of large numbers of maize genotypes.

Inbred lines had smaller root diameter and lower root pull resistance than hybrids. The heterosis on root diameter, was 140%, while in case of root pull resistance the heterosis is 123%. However, significant variation can be observed in the root pull resistance of inbred lines. The root pull resistance was 37 kp for the inbred lines with the weakest resistance, and 129 kp for the strongest ones. The low level of heterosis and the wide range of variation enable efficient selection during inbreeding.

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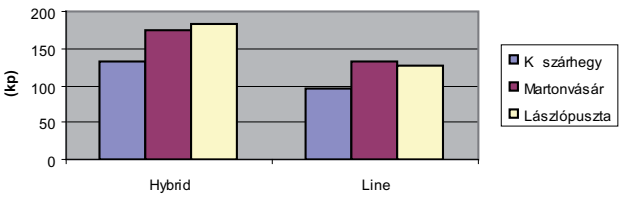

Figure 5: **Root pull values of the hybrids and lines in different locations (First sample, 2008)**

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