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1. Lisbon and the IHC2010.
2. Somatic embryogenesis, in vitro genetic manipulations, and plant regeneration in ornamental ginger *(Hedychium* J. Koenig) for the induction of polyploidy and mutagenesis. Photograph by courtesy of Hamidou F. Sakhanokho.
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6. Mutagenic effect of sodium azide on ornamental ginger: Variegated plant obtained by treating *Hedychium muluense* x *Hedychium* 'White Starburst' embryogenic callus with 20 mM NaN_3 for 6 hours. Photograph. by courtesy of Hamidou F. Sakhanokho.

Similar Yield Reductions under Different Growing Conditions Caused by the Introgression of Genetic Resistance to TYLCV into Traditional Tomato Cultivars

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Keywords: *Ty-1,* TYLCV *(Tomato yellow leafcurl virus),* greenhouse, open air

Abstract

We are conducting a breeding program to introgress resistance to several viral diseases (ToMV, TSWV, and TYLCV, the most relevant in south-eastern Spain) into Spanish traditional tomato cultivars. In order to determine the possible negative effect of the introduction of TYLCV resistance, 70 F2 plants from the selfing of an advanced breeding line of the 'Muchamiel' cultivar, homozygous for the resistance alleles Tm-2a, Sw-5, and heterozygous for Ty-1 were evaluated for yield. Plants were grown under greenhouse in an autumn-winter cycle, at the Estación Experimental Agraria de Elche (IVIA), Elche (Alicante). Yields were relatively high for a traditional variety, since fruit weight was 5.2 kg/plant. The Aps-F2 marker, linked to the *Ty-1* gene was used to confirm that the genotypes in the F_2 population followed the expected ratios (¼:½:¼). Plants homozygous for the TYLCV resistance gene (genotype *Ty-l!Ty-1)* showed on average a 33% yield decrease with respect to the susceptible plants (genotype *ty-l/ty-1),* while the heterozygous plants (genotype *Ty-1/ty-l)* experimented only a 13% yield decrease. In a previous field experiment conducted under open air, in a different growing cycle (spring-winter) and in a lower yield environment (2.4 kg of fruit weight per plant), the percentages of yield reductions, 31 % for the resistant homozygote and 8 for the heterozygote, were very similar to those determined in the present experiment.

INTRODUCTION

We are conducting a breeding program, using marker assisted backcrossing, for the introduction ofthree dominant genes *(Tm-2", Sw-5,* and *Ty-1)* that confer resistance to the three most relevant viruses in south-eastem Spain (ToMV, TSWV and TYLCV, respectively) into 'Muchamiel' and 'De la Pera' Spanish traditional cultivars. The genes *Tm-2"* and *Sw-5* come from the wild tomato *Solanum peruvianum* L. and *Ty-1* originated in the accession LA 1969 of another wild tomato species, *Solanum chilense* (Dunal) Reiche. As a preliminary result of the breeding program, we have obtained promising pre-breeding materials, which have to be further adapted to the specific agroclimatic conditions of different localities (Ruiz and García-Martínez, 2009).

However, the introgressed genes and/or to the linkage drag could also have negative effects (Brown, 2002). In particular, the introgression of *Tomato yellow leafcurl virus* (TYLCV) resistance seems to affect seriously some important agronomic traits, as yield (Alonso et al., 2008).

In the present work we have evaluated, in a greenhouse growing cycle, the effect of the introgressed genetic resistance to TYLCV (gene *Ty-1)* in advanced breeding lines of 'Muchamiel' type. We have compared the results with those obtained in previous experiments conducted under different growing conditions.

MATERIAL ANO METHODS

In order to determine the possible negative effect of the introduction of TYLCV resistance, 70 F_2 plants segregating for TYLCV resistance were evaluated for yield. Plants were obtained from the selfing of an advanced breeding line (selected from a five

backcross generation) of the 'Muchamiel' cultivar, homozygous for the resistance alleles *Tm-2a, Sw-5,* and heterozygous for *Ty-1.* Plants were grown under greenhouse in an autumn-winter cycle, at the Estación Experimental Agraria de Elche (MA), Elche (Alicante). Yields were relatively high for a traditional cultivar, since fruit weight was 5.2 kg/plant. The Aps-F_2 marker (Fig. 1), linked to the *Ty-1* gene was used to confirm that the genotypes in the F_2 population followed the expected ratios (¼:½:¼).

RESULTS AND DISCUSSION

The yield of the plants homozygous for the TYLCV resistance gene (genotype *Ty-1/Ty-1)* was 1730 g/plant lower than that of the homozygous susceptible plants (3461 g/plant vs. 5191 g/plant; Fig. 2). This suppose on average a 33% yield decrease for the homozygous resistant plants with respect to the susceptible plants (genotype *ty-1lty-1),* while the heterozygous plants (genotype *Ty-1/ty-l)* experimented only a 13% yield decrease (612 g/plant).

In a previous field experiment (Alonso et al., 2008) conducted under open air, in a different growing cycle (spring-winter) and in a lower yield environment (2.4 kg of fruit weight per plant), we obtained very similar yield reductions to those determined in the present experiment (Table 1). The percentages of yield reductions in this previous experiment were 31 % for the resistant homozygote and 8% for the resistant heterozygote, compared with the susceptible plants.

It would be desirable to develop plant materials with shorter introgression segments, in order to eliminate negative effects of the linkage drag (Yuanfu et al., 2009). However, suppressed recombination in the chromosomal region around the resistance gene seems to make inefficient the process of backcrossing as an approach to reduce linkage drag. A significant achievement would be the identification of molecular markers closely linked to the resistance genes.

CONCLUSIONS

The percentages of yield reductions due to the linkage drag introduced with the TYLCV resistance were very similar in two experiments performed under greenhouse and in the open air, and in very different yield environments. Heterozygous resistant plants showed an allowable yield decrease (ranging between 8 and 13%), but the 30% decrease showed by homozygous resistant plants point to the difficulty in developing TYLCV resistant varieties that are horticulturally acceptable.

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Tables

Table 1. Yield parameters evaluated in 96 F_2 plants segregating for TYLCV resistance, grown in the open air (Alonso et al., 2008).

	Number of fruits per truss	Mean fruit weight (g)	Fruit yield (g/plant)
Significance[1]	**	**	**
df	93	93	93
Ty-1 genotype			
RR	3.5 a	97.5 a	1670 a
Rs	4.5 b	111.3 b	2237 b
ss	5.1 b	121.2 b	2418 b

[1] **Significant at P<0.05.

RR is the homozygote for the resistant allele *Ty-1,* ss the homozygote for the susceptible allele *ty-1* and Rs is the heterozygote.

Figures

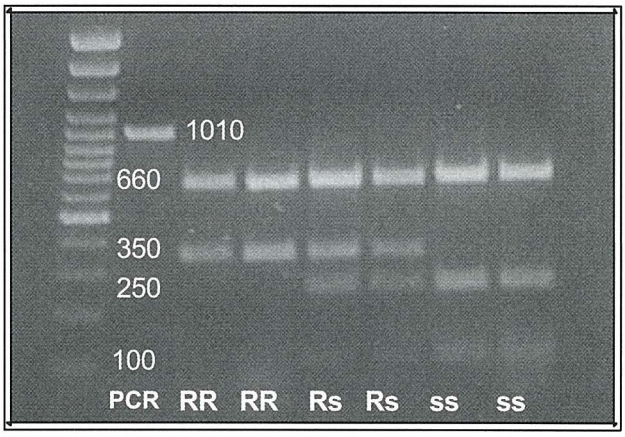

Fig. 1. The Aps-F2 marker was used to determine the genotypes in the F_2 population segregating for TYLCV resistance. RR is the homozygote for the resistant allele *Ty-1,* ss the h?mozygote for the susceptible allele *ty-1* and Rs is the heterozygote.

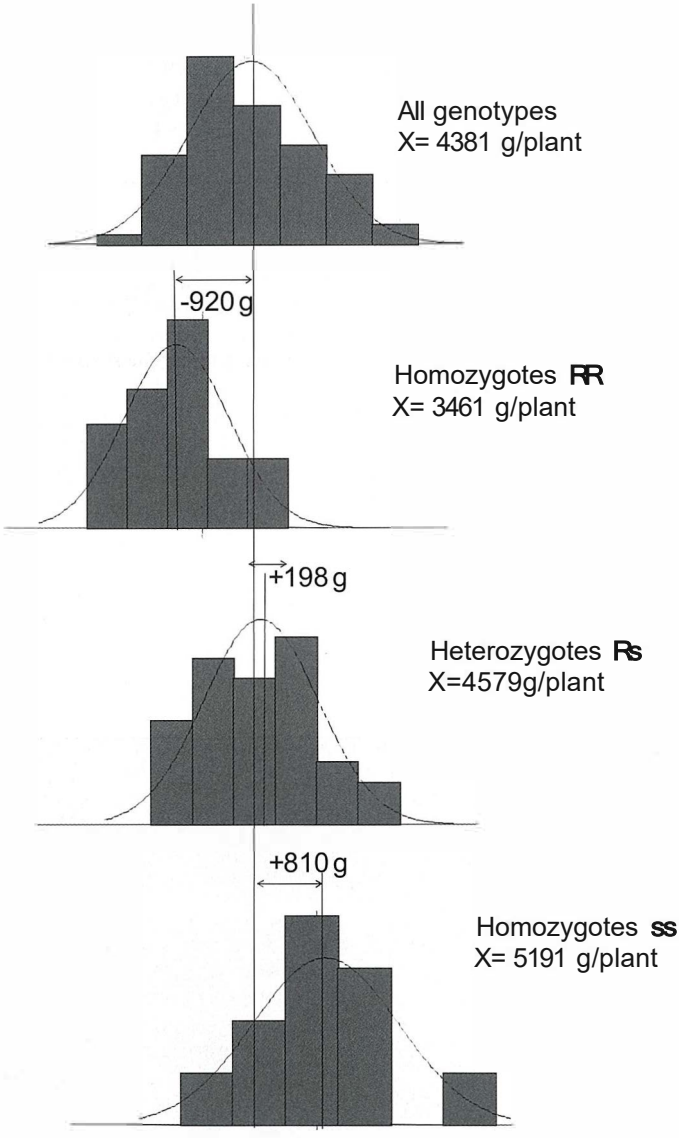

Fig. 2. Distributions of fruit yield per plant according to their genotype for resistance to TYLCV. RR is the homozygote for the resistant allele *Ty-1,* ss the homozygote for the susceptible allele *ty-1* and Rs is the heterozygote.