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Incidence of and yield loss caused by maize rayado fino virus in maize cultivars in Ecuador

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Abstract Three sowing date trials, each planted with one cultivar, were performed to measure the natural incidence of the Maize rayado fino virus (MRFV). The lowest incidences (1–6%) were obtained at the sowing dates normally practised in the tested regions. Earlier or later sowing dates had higher to much higher incidences (up to 18 and 32%). Two cultivar trials, one with four cultivars and one with eight cultivars, showed significant differences in incidence, ranging from 14.0% in 'Iniap-160' to 2.0% in 'Cadet-2'. In one trial with plots of 1000 m^2, the cultivar Iniap-122 was sown at three sowing dates. In each plot, plants that developed MRFV symptoms at the 8–10 leaf stage, at the 12–14 leaf stage and at the emergence of tassels were marked. Marked MRFV-affected plants were compared with non-MRFV-affected plants in their neighbourhood to estimate yield loss due to MRFV. The yield losses at the three sowing dates were 2.5, 1.6 and 4.8%, respectively. It was concluded that the yield loss due to MRFV is quite small provided sowing is restricted to the normal sowing period.

Keywords Cultivar · *Dalbulus maidis* · Leafhopper · Resistance · Sowing date

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Introduction

Maize rayado fino is a disease widespread in Central America and Mexico (Gamez, 1969; Nault et al., 1980). It has also been reported from various regions in South America (Gamez, 1980).

It was first described as a strain of the corn stunt virus (Ancalmo & Davis, 1961), but Gamez (1969) identified it as a virus, distinctly different from corn stunt. Of the "Maize rayado fino virus" (MRFV), at least two other strains are known; the Brazilian maize streak virus (Costa et al., 1971) and the "Maize rayado colombiano virus" (Martinez-Lopez & Rico de Cujia, 1977). They have similar properties but are serologically different.

The virus is transmitted predominantly by the leafhopper *Dalbulus maidis* (Toler et al., 1985). The host range of the virus is restricted to the cultivated *Zea mays,* the various *Zea mays* subspecies of teosinte and *Rottboellia exaltata,* a weed related to maize and introduced into the Americas from tropical Asia (Nault et al., 1980). This latter species may serve as an overseasoning host for the virus in Latin America and the southern US. *Dalbulus maidis* retains the virus for a prolonged time (Gamez, 1969) but is not transmitted transovarian (Gonzalez & Gamez, 1974). The virus is not mechanically transmissible (Gamez, 1976).

Symptoms start to appear some 7–14 days after exposure to viruliferous leafhoppers. They consist of small chlorotic spots along the leaf veins that become elongated and more numerous giving the impression

of fine striping ("rayado fino"). Later, a more general chlorosis may develop. Ears are reduced in size (Gamez, 1969; Toler et al., 1985). Early infections give the largest yield losses and these losses can be considerable in Central America (Gamez, 1976). Toler et al. (1985) observed differences in susceptibility, in terms of incidence (41–100%) and percentage stunting (25–50%), among 58 North American maize accessions, exposed to viruliferous leafhoppers.

MRFV resembles the Maize Streak Virus (MSV) of the old world which is transmitted by leafhoppers of the genus *Cicadulina* but is not related to it. The symptoms on maize cultivars infected with MSV vary from no symptoms to different severities of symptoms expressed in earlier or later appearance of the symptoms which develop faster or more slowly (Barrow, 1992; Rodier et al., 1995) and this seems also the case with the resistance to MRFV (Toler et al., 1985).

In the maize producing areas of the provinces Pichincha and Imbabura in Ecuador, MRFV occurs frequently, especially when sown early. In order to decide whether breeding for resistance is possible and desirable, information about some aspects of this disease was needed. To this end, several experiments were carried out in two regions where MRFV occurs frequently.

Materials and methods

Sowing date trials

At each of the three localities in the province of Imbabura, one maize cultivar ('Chaucho' at Coñaqui and Tunibamba, 'INIAP-122' at Los Ovalos) was sown at three or four consecutive dates. Per location and sowing date, a plot measuring 50 m × 20 m (25 rows 0.8 m apart) was sown, each plot in a different field. At Coñaqui, 2200 m altitude, the normal sowing period of maize is very early in July. At Tunibamba and Los Ovalos, 2500 m altitude, the normal sowing period is the first week of October. The agronomy applied was the one normally applied by the farmers, same row and plant distance (about 50,000 per ha), no fertilizers, no pesticides and weeding twice. The plants were assessed for the presence of MRFV symptoms at the milky stage in Coñaqui, at the 12th leaf stage (12th leaf unfolded) in Tunibamba and at two or three stages in Los Ovalos. The percentage plants with MRFV symptoms (incidence) was assessed in the field on six samples of 100 plants each per sowing date, per location and per growth stage. To get an even sampling across the whole field, the plot was divided into six equal parts, each consisting of four rows, the middle row being left out.

Cultivar trials

At a site in Cadet, province of Pichincha, two cultivar trials were carried out at sowing dates conducive to the Maize rayado fino virus. At the first trial, four promising cultivars were sown on four adjacent plots measuring 15.0 m × 12.0 m (15 rows 0.8 m apart) on 24th October.

The second trial, sown on 25th November at the same location, was a yield trial with eight cultivars. Each plot measured 5.5 m × 3.2 m (4 rows 0.8 m apart). The trial design was a complete block design with four replicates. At the stage of emerging tassels, the incidence of MRFV was assessed. Also the days to male flowering and the kernel yields in tonnes per hectare were determined.

Yield loss estimates

The cultivar Iniap-122 was sown on three plots, each of 1000 m^2, on three dates in Los Ovalos. This is the third sowing date trial described in the section "sowing date trials" above. In each plot, plants were marked when MRFV symptoms appeared at three plant stages, at the 8–10 leaf stage, at the 12–14 leaf stage and at the emergence of the tassel. For each plant with symptoms, a healthy plant in its neighbourhood was marked as well. At maturity, the kernel yield of each plant of the marked plant pairs and of the whole plot was measured in kilograms after the kernels were brought to a moisture level of 15%. A few plants, marked initially as healthy developed disease symptoms later. These pairs were not taken into account.

Results

Sowing date trials

The incidence of MRFV at Coñaqui decreased from 18% on the sowing of 10th of June to 16% on the sowing of 20th of June to only 1% on the normal sowing date of 1st of July. At the two other locations, with the first days of October being the normal sowing period,

Table 1 Incidence of "Maize rayado fino virus" in maize cultivar Chaucho on four sowing dates in Tunibamba

Sowing date	Incidence
August 15	6
September 15	4
October 1[a]	3
November 20	32

[a]Normal sowing date

Table 2 Incidence (%) of "Maize rayado fino virus" in maize cultivar Iniap-122, sown on three dates and evaluated at three development stages in Los Ovalos

	Development stage			
Sowing date	V8-10 leaves	V12-14 leaves	Tassel emerging	Total
August 28	–	6.7	1.6	8.3
October 3[a]	1.2	2.0	3.0	6.2
October 31	6.1	7.6	4.4	18.1

[a]Normal sowing date

Table 3 Incidence of "Maize rayado fino virus" in four maize cultivars in Cadet

Cultivar	Incidence (%)
Población-86	7.3
ADT × Hybridos Pob-88	6.8
Iniap-180	2.4
Iniap-180 × Hybridos Pob-88	2.2

earlier sowing did not result in a significantly increased incidence, but later sowing did (Tables 1 and 2). At Los Ovalos, there were no clear tendencies in frequency of appearance of symptoms with plant development stage.

Cultivar trials

The incidence level in both trials was moderate (Tables 3 and 4). Nevertheless, these incidences differed significantly between cultivars (Table 4). The cultivars Población-86 and Iniap-180 showed the same incidence pattern in the two trials. The five cultivars: Cadet-1, Iniap-180, Iniap-176, S.J. Minas and Cadet-2 share a significant lower incidence compared with 'Poblacion' and 'INIAP-160'. They also share the entry Guatemalteco in their parentage. Their resistance may therefore

Table 4 Incidence of "Maize rayado fino virus" (MRFV), days to flowering and kernel yield in tonnes per hectare in eight maize cultivars in Cadet

Cultivar	Incidence MRFV	Days to flowering	Yield
Iniap-160	14.0 a*	102	2.7 ab*
Población-86	10.7 ab	82	3.3 ab
Iniap-151	8.3 abc	90	3.1 ab
Cadet-1	4.3 bc	108	3.5 a
Iniap-180	4.1 bc	110	3.4 ab
Iniap-176	2.5 bc	114	2.6 ab
S. J. Minas	2.3 c	126	2.1 b
Cadet-2	2.0 c	106	3.6 a

*Means within columns with the same letter do not differ according to Tukey at 5% probability

be derived from this entry, introduced in 1962 from Guatemala (Moreno, 1984).

Yield loss estimates

Table 5 presents the number of plant pairs taken at the three plant stages and the loss in kernel yield caused by the virus. The decrease in kernel weight per plant tended to be smaller the later the symptoms appeared. The average yield loss percentages per plant (Table 5) were used to estimate the yield loss caused by MRFV per area (Table 6). From the measured (observed) plot yields, the number of plants with MRFV symptoms and the percentage yield loss due to this virus, the potential kernel yield (the yield in the absence of the MRFV) and so the kernel yield loss due to this virus per area were calculated (Table 6).

Discussion

From the point of view of having the least damage caused by the MRFV, the normally practised sowing periods appear to be the best. Also, it is clear that resistance of a quantitative type is available, which agrees with the observations of Toler et al. (1985). Decreased levels of MRFV damage through breeding for increased resistance is therefore a clear possibility, but it is unlikely that a breeding effort would be worthwhile in the light of the present low to moderate yield losses due to this virus.

The yield losses observed here tend to be more serious the earlier the infection, which confirms the observations of Gamez (1976). The estimated yield losses

Table 5 Percentage loss of kernel yield of maize plants showing Maize rayado fino virus symptoms at three plant development stages at three sowing dates in maize cultivar Iniap-122 in Los Ovalos

	Development stage							
	V8-10 leaves		V12-14 leaves		Tassel emerging		Total/Average	
Sowing date	Plant pairs	Yield loss (%)	Plant pairs	Yield loss (%)	Plant pairs	Yield loss (%)	Plant pairs	Yield loss (%)
August 28	–	–	37	27	22	35	59	30.0
October 3[a]	8	51	32	34	43	14	83	25.3
October 31	19	35	82	25	27	25	128	26.5

[a]Normal sowing date

Table 6 Number of plants per plot, number of plants infected per plot, potential yield in kg per plot, observed kernel yield in kg per plot[a], estimated yield loss in kg per plot, and estimated percentage yield loss caused by MRFV in cultivar Iniap-122 at three sowing dates in Los Ovalos

Sowing date	Plants	Plants inf.	Pot. yield	Obs. yield	Yield loss	Yield loss, %
Aug. 28	3716	307	286.2	279.1	7.09	2.48
Oct. 3	3879	239	213.3	210.0	3.32	1.56
Oct. 31	3429	618	223.0	212.4	10.65	4.78

[a]Grains adjusted to 15% moist

per area as shown in Table 6 indicate that the yield damage due to this virus suffered by farmers will be quite small provided they stick to the normal sowing period.

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