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PEPPER VIRAL DISEASES AFFECTING PRODUCTION OF SELECTED GERMPLASM AT CARDI HOT PEPPER BREEDING CENTRE

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ABSTRACT: Hot pepper production in the CARICOM countries occur using seeds of open-pollinated landraces from the region, with West Indies Red being the dominant cultivar planted followed by Scotch Bonnet. The Caribbean Agricultural Research and Development Institute (CARDI) developed West Indies Red in an effort to diversify the region's crop commodity portfolio and because of the interest in Caribbean hot peppers on the export markets (USA, Canada, UK). CARDI's hot pepper improvement program has progressed by collecting germplasm of the region, conserving and evaluating these and developing new improved open pollinated landrace cultivars. It has been noted that among the constraints (irrigation, fertilization, pest management, post harvest handling) to field production, virus diseases are probably the most significant. Attempts have therefore been made in cooperation with the Asian Vegetable Research Development Center (AVRDC) to precisely identify the viral disease profile occurring in production plots. The predominant viruses identified in 2004 were CMV and PVY. It is planned that new germplasm resistant to these viruses will be introduced from Taiwan (AVRDC) and screened in Barbados. Accessions found to be resistant in the Caribbean will be used to develop new cultivars via hybridization and selection of outstanding progeny.

Key words: *Virus diseases, hot pepper, Capsicum chinense Jacq., aphids, PVY, CMV*

INTRODUCTION

Caribbean hot peppers originated in a geographic expanse encompassing Northern Brazil, the Guianas, the Antilles and Central America. This area represents the centre of greatest diversity of *Capsicum chinense* and *Capsicum frutescens*. The variation in Caribbean landrace hot pepper varieties is significant, manifesting differences in size, color, shape, aroma, pericarp thickness and pungency of berries. The two main varieties grown in the English Caribbean are West Indian Red (red, blocky shaped berry with high pungency) and Scotch Bonnet (yellow berry, with a characteristic "lobed bonnet" shape, unique aroma and the highest pungency of the region's hot peppers). The fresh fruit market and processors display a high demand for both these berry types. Additionally, international markets have also developed a demand for these unique Caribbean signature agricultural commodities with current demand outstripping supply. The Caribbean Agricultural Research and Development Institute (CARDI) has made a major contribution to the regional hot pepper industry by developing and producing seed of West Indies Red. In an attempt to make available additional improved planting materials, which combine desirable agronomic traits and marketable characters, CARDI launched a hot pepper breeding

programme in 1997. This programme has resulted in the collection and improvement of a number of landraces from across the region. Successful execution of a breeding program requires precise knowledge of production constraints including pathological, entomological, agronomic and irrigation factors. This study focuses on the impact of viral diseases on hot pepper productivity. It builds on initiatives of CARDI in 2001 when efforts were made to identify the viruses present in pepper trials using the ELISA technique. In 2004 the objective was to specifically identify those viruses affecting yield of select germplasm at the CARDI Hot Pepper Breeding Centre at Graeme Hall, Christ Church, Barbados. The work was done in collaboration with the Asian Vegetable Research and Development Center (AVRDC). This paper presents the prevalent viruses identified and the consequence of their occurrence on yield.

MATERIALS AND METHODS

Eight varieties collected from across the region were used in the trial. The accession names and their sources of origin are shown in Table 1. West Indies Red was used as the check variety.

Table 1: Regional hot pepper landraces and improved selections from the Caribbean

Accession name	Genus	Species	Source country
Cayenne	<i>Capsicum</i>	<i>chinense</i>	Guyana
CARDI Green	<i>Capsicum</i>	<i>chinense</i>	Barbados
CARDI Red	<i>Capsicum</i>	<i>chinense</i>	Barbados
Red Congo	<i>Capsicum</i>	<i>chinense</i>	Trinidad
Red Flat	<i>Capsicum</i>	<i>chinense</i>	St. Lucia
Scotch Bonnet	<i>Capsicum</i>	<i>chinense</i>	Jamaica
Tiger Teeth	<i>Capsicum</i>	<i>chinense</i>	Guyana
West Indies Red	<i>Capsicum</i>	<i>chinense</i>	Antigua

The trial was arranged in a randomized complete block design comprising three replications with plots separated by 1 m wide paths. The elementary plot size was 400 x 800 cm and accommodated a total of 50 plants including the border rows. Drip irrigation was used to supply water (45 m³ per acre) to plants every two days when there was no rainfall. The drip lines were also used to fertigate the trial. After applying a side dressing 12-12-17-2Mg three days after transplanting, 21-0-0 applied via the drip lines weekly for the first six weeks after transplanting to the field. From the seventh week fertigation was done fortnightly using 9-18-9.

Observations plants showing various virus symptoms were made and sample collections were taken during the peak hot pepper harvesting period in open field cultivation. Incidence of viral symptoms was first evaluated by estimating the percentage of plants showing characteristic symptoms in each plot. Typical symptoms included yellowing, yellow mottle, yellow mosaic, reduction in leaf size, curling of leaves, leaf distortion and narrowing of leaves. The AVRDC was approached to conduct the screening of accessions on behalf of CARDI because of their expertise in the area and their ready access to wide range of antibodies and primers encompassing many anticipated viral diseases in Barbados based on symptoms described as occurring in the field and previous experience. A small branch or tip of representative plants showing virus symptoms was collected, placed between a paper towel (to absorb excess moisture), inserted in a plastic bag and sent to AVRDC for further analysis. DAS-ELISA was used for the detection of cucumber mosaic virus (CMV), chilli veinal mottle virus (ChiVMV), potato virus Y (PVY), tomato mosaic virus (ToMV), pepper mild mottle virus (PMMV), tomato

spotted wilt virus (TSWV), watermelon silver mottle virus (WSMV), and broad bean wilt virus (BBWV). PCR was used for the detection of geminivirus (GV), tomato chlorosis virus (ToCV) and tomato infectious chlorosis virus (TICV).

Yield of fresh berries was harvested from the 24 interior plants (excluding the border rows) and analyzed.

RESULTS

Harvests of mature berries for each variety are shown in Table 2. Yields represent totals per entry for three pickings. It is noted that the control, West Indies Red, had the highest yield, while harvests from Tiger Teeth and CARDI Red though somewhat less were not statistically different from the control. All other accessions had yields that were highly significantly worse than West Indies Red. Note also that yield for the control decreased as pickings increased, while Tiger Teeth and CARDI Red peaked before decreasing.

Table 2: Yields (kg) of mature berries by pickings per variety of eight Caribbean hot peppers grown under field conditions in Barbados during the first cropping season in 2004

Accession Name	Pickings					
	1	2	3	Total	Mean	Difference from Control
Cayenne	11.8	8.8	3.1	23.68	7.893	20.207**
CARDI Green	7.6	14.9	6.3	28.83	9.610	18.490**
CARDI Red	21.5	29.6	21.1	72.20	24.067	4.033 ^{ns}
Red Congo	8.6	21.2	11.2	41.00	13.667	14.423**
Red Flat	15.1	19.4	3.9	38.40	12.800	15.300**
Scotch Bonnet	19.1	13.6	14.5	47.20	15.733	12.367**
Tiger Teeth	23.1	30.2	21.4	74.70	24.900	3.200 ^{ns}
West Indies Red	31.6	29.0	23.7	84.30	28.100	

p = number of pickings = 3; df = 14; Error Mean Square = EMS = 14.36;

($t_{0.05}$) = 2.145; ($t_{0.01}$) = 2.977

LSD_{0.05} = ($t_{0.05}$) $\sqrt{\{(2 \times \text{EMS}) / p\}}$ = 6.636

LSD_{0.01} = ($t_{0.01}$) $\sqrt{\{(2 \times \text{EMS}) / p\}}$ = 9.210

** = Highly significantly worse than the control

ns = Not statistically different from the control

Yield in hot pepper would be influenced by such factors as number of fruits per plant at harvest, weight per berry, size of berry and number of bearing branches per plant. Cayenne and Red Flat had very high number of fruits per plant at picking while Red Congo had heaviest average fruit weight (data not shown), yet these accessions did not feature impressively when compared to the control. The reason for their poor yield performance was their high susceptibility to viral attack (Table 3). Table 4 summarizes the viruses identified on the various accessions, some of the field symptoms and confirmed presence or absence of CMV and PVY.

Table 3: Percent of plots showing viral symptoms in CARDI Yield Trial 2004

Accession	Rep 1	Rep 2	Rep 3	Average
CARDI Red	10	20	75	35
CARDI Green	50	35	23	36
West Indies Red	18	27	9	18
Red Congo	88	91	97	92
Red Flat	85	90	80	85
Tiger Teeth	35	75	25	45
Scotch Bonnet	95	80	80	85
Cayenne	97	97	97	97

Table 4: Virus tests of hot pepper (*Capsicum sp.*) lines in CARDI Yield Trial 2004

Accession	Symptoms		CMV ³	P V Y	Comments ⁵
	Expression ¹	% ² plants			
CARDI Red	c, m, ns (y)	35	+ ⁴	+	50% CMV; 50% PVY
CARDI Green	M, b, m, c, ns	36	+	+	66% CMV ; 33% PVY
West Indies Red	c, m, ns	18	+	+	50% CMV ; 100 % PVY
Red Congo	c, m, ns	92	+	+	66% CMV ; 22 % PVY
Red Flat	c, m, ns	85	+/-	+	100 % CMV ; 100 % PVY
Tiger Teeth	c, m, ns, dist, nl, (y)	45	+	+	33 % CMV; 33 % PVY
Scotch Bonnet	c, m, ns	85	+	+	100 % CMV; 100 % PVY
Cayenne	c, m, ns	95	+	+	75 % CMV; 100 % PVY

(Samples collected July 27 2004)

¹ c = crinkle; m = mottle; ns = necrotic spots; y = yellowing; dist = distortion; M = mosaic; nl = narrow leaves; b = blistering; () = mild symptoms;

² % plants = average percentage of plants in the plots (three replicates) showing more than 40% of foliage expressing viral symptoms

³ CMV = cucumber mosaic virus, PVY = potato virus Y, BBWV = broad bean wilt virus. Other viruses, such as ToMV = tomato mosaic virus, PMMV = pepper mild mottle tobamovirus, TSWV = tomato spotted wilt virus, WSMV = watermelon silver mottle virus, GV = geminivirus, ToCV = tomato chlorosis virus, TICV = tomato infectious chlorosis virus were tested but gave a negative reaction

⁴ +/- = weak reaction; + = positive reaction (OD value > 3 x OD of healthy check)
- = no reaction (OD value the same or below that of healthy check)

⁵ Comments = percentage of samples testing + or - in the lab for CMV and PVY; 4 to 9 samples tested; an accession was scored overall + or - if 50% or more of the samples so tested.

Flower bud moth, mites, thrips and to lesser extent aphids were the predominant insects observed during the growing season. The flower bud moth lowers yield by causing premature bud and fruit drop while mites, thrips and aphids reduced yield directly (insect “damage”) and indirectly (vectors for virus). West Indies Red and Tiger Teeth showed the ability to quickly recover once chemical treatment was applied to counter insect presence.

As the season progressed, the incidence of virus symptoms gradually increased among accessions but was especially severe in overwhelming Red Flat, Red Congo and Cayenne.

It can be seen from the results of the virus tests shown in Table 4 that CMV and PVY were the most common viruses that occurred in the field. There were also reports of BBWV and PMMV on some accessions. Interestingly, PCR amplification did not detect the presence of Gemini virus in the field.

Symptoms expressed by infected plants included crinkling, mottling, necrotic spots, yellowing, and mosaic on the leaf. Individual plant expression of symptoms varied from mild (e.g. CARDI Red, CARDI Green) to high (Red Congo and Tiger Teeth). West Indies Red had the lowest percentage (18%) of plants within the plots showing symptoms while Red Flat (100%) and Red Congo (85%) were at the other extreme (see Table 3). Tiger Teeth and Red Flat displayed a pronounced leaf distortion and narrowing of the leaves in many plants in the trial plots (see Figure 1).

Flowering, fruit-set and harvesting of berries seems to have been affected by the incidence of virus as pickings occurred at 2 to 3 week intervals instead of the anticipated weekly basis. Spraying with insecticides to control vector insects and application of fertilizers did facilitate the plants recovery to normal productivity. Though West Indies Red and CARDI Red did recover to “adequate” yields, most accessions (Red Congo, Red Flat, Scotch Bonnet, Cayenne) continued in serious decline, with no further flowering and very little berries to harvest. The experiment was therefore curtailed after three pickings - much earlier than intended

DISCUSSION

Green and Kim (1991) reported that approximately 35 viruses are known to affect pepper globally. In the Caribbean, susceptibility to viruses has been noted among regional accessions (Jones, 1988; Jones and Cooper, 1992). In 2001 screening against 10 viruses was conducted in Barbados (CARDI Barbados Annual Report, 2001). Results showed the presence among samples tested of TEV (40%), PVY (90%), CMV (84%), Gemini viruses (30%) and PMMV (10%).

This study screened for the presence of cucumber mosaic virus (CMV), potato virus Y (PVY), broad bean wilt virus (BBWV), tomato mosaic virus (ToMV), pepper mild mottle tobamovirus (PMMV), tomato spotted wilt virus (TSWV), watermelon silver mottle virus (WSMV), geminivirus (GV), tomato chlorosis virus (ToCV), tomato infectious chlorosis virus (TICV). The vectors involved in their transmission - aphids, whiteflies - both *Bemisia tabaci* G (sweet potato whitefly) and *Trialeurodes vaporariorum* (glasshouse whitefly), aphids and thrips have all been confirmed as being present in Barbados. Additionally it is known that PMMV can be transmitted by seed and that ToMV is transmitted mechanically.

The results show that CMV and PVY were the most prevalent viruses confirming the findings earlier reported by L. Paulraj that these two viruses had the highest occurrence (84% and 90% respectively) among samples in Barbados (CARDI Barbados Annual Report 2001). It is

instructive to note that unlike the 2001 survey, no Gemini virus identified among the selected germplasm screened.

All of the accessions studied showed susceptibility to PVY and CMV (see comments column of Table 4) though only CMV consistently resulted in “+” rating since more than 50% of the 9 samples tested for each accession were positive. One can therefore conclude CMV was the more dominant virus in 2004 at the CARDI Hot Pepper Breeding Centre. Further, West Indies Red, CARDI Red, CARDI Green and Tiger Teeth were the most tolerant of the yield trial entries. More importantly, CARDI Red and West Indies Red showed the capacity to rebound from insect attack after spraying with insecticides going on to give adequate yield. This would strongly suggest that these accessions have some level of tolerance to the prevailing viruses. It would have in fact been feasible to extend the trial to a further 3 to 5 pickings (based on field observations since the field was not immediately destroyed, even though no harvestings was actually effected). The other entries did not however recover even after insecticidal sprayings and fertigation suggesting the virus(es) continued to replicate in the plant eventually leading to death. Also of great significance is the observation that even though CARDI Red, Tiger and West Indies Red were affected by the virus, these accessions still had substantial yields (mean of 24 to 28 kg/picking) while the more susceptible treatments had rather low yields (see Table 3). One can therefore speculate that if accessions can be introduced with similar or higher levels of tolerance to CMV and PVY, then these can be hybridized to regional germplasm with outstanding berry characteristics resulting in progeny with high yield potential in this environment.

H. Adams (CARDI Barbados Annual Report 1999) reported yields of 12,000 lb per acre for West Indies Red at spacings used in this trial. This implies a yield reduction of approximately 50% for West Indies Red in the 2004 yield trial. The reduction was as a result of reduced number of berries per picking and loss of picking (reduced from 8 to 3). Even though comparable data is not readily available for the other accessions one can estimate that yield losses on the order of 50 to 70 % ensued as a result of the viral diseases. Losses as high 100 % has been recorded in pepper production fields (Green and Kim, 1991).

The abnormally low yield of CARDI Green cannot be readily explained at this time as the plants grew vigorously, had the greatest plant height and second widest canopy (data not shown) along with dark green dense foliage.

CONCLUSION

The occurrence of viruses in the pepper fields can have drastic negative effect on the yield which can impact on pepper production nationally. It is critical that new varieties be introduced and evaluated for virus resistance in the Caribbean environment. Tolerant/resistant germplasm identified can be used to develop new improved cultivars via hybridization with outstanding Caribbean landraces. Progeny resulting from these crosses can then be selected for virus tolerance/resistance combined with ideal ideotype, outstanding organoleptic traits and eventually new improved cultivars for Caribbean requiring less farmer inputs for production.

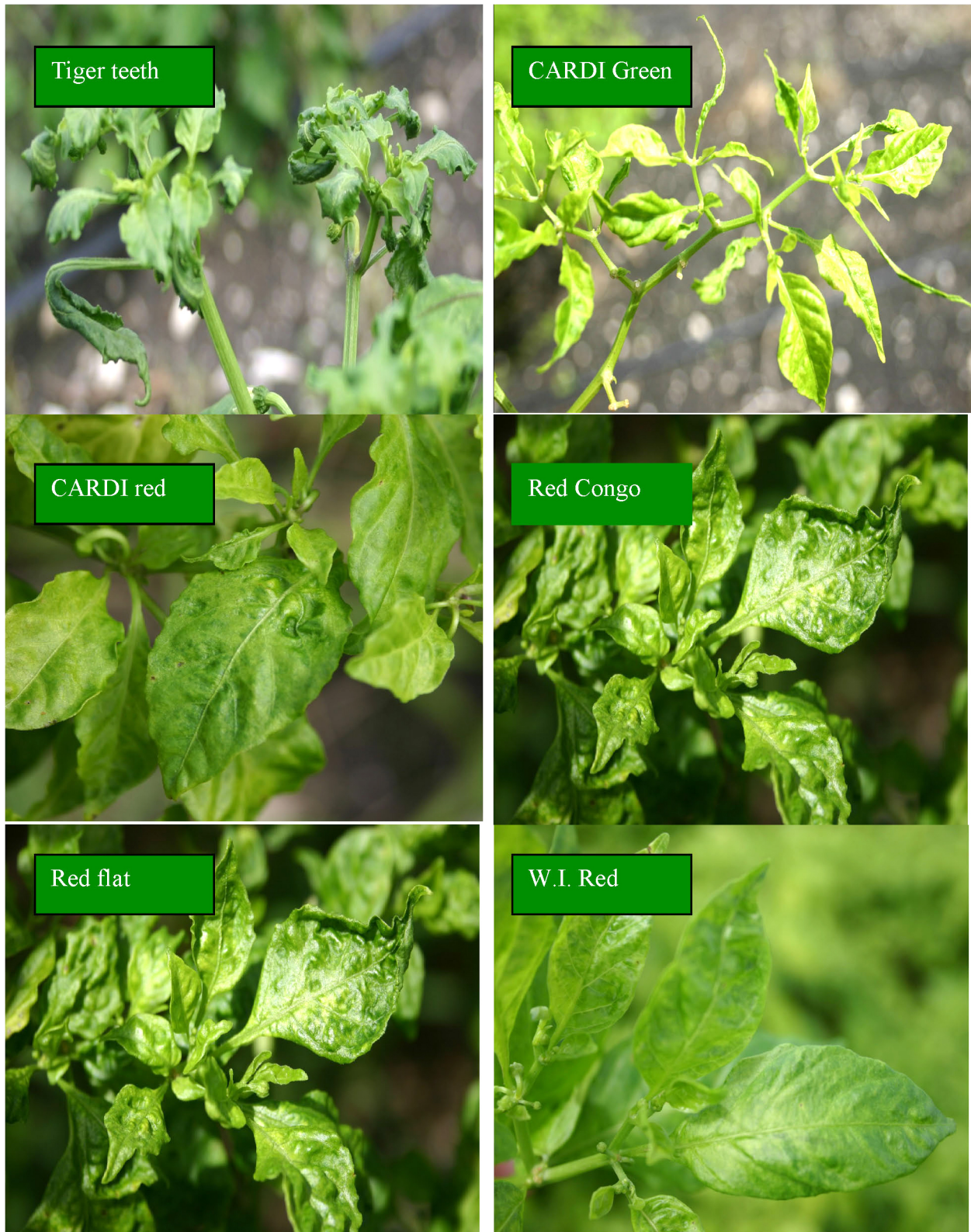


Figure 1: Viral leaf symptoms occurring on leaves of selected germplasm in CARDI yield trial

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