CARIBBEAN FOOD CROPS SOCIETY

PROCEEDINGS

ELEVENTH ANNUAL MEETING

A YELLOWING AND DIE-BACK SYNDROME OF PIGEON PEA *(CAJANUS CAJAN* (L.) MILLSP.)

by

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SUMMARY

Certain cultivars of pigeon pea *(Cajanus cajan (L.)* Millsp.) when grown at one site in Jamaica, display a yellowing of new leaves and progressive dieback, leading to premature death and loss of later bearings. The symptoms do not correspond with any reported disease of pigeon peas. Leaf analysis suggests that Mn deficiency may be a primary cause of the syndrome. Foliar sprays and soil drenches of MnS04 and complete fertilizer do not prevent or reverse the symptoms. The possible relationship of nematodes to incidence of the syndrome has been investigated; nematicides increased yields but did not prevent yellowing and dieback.

INTRODUCTION

Early in 1970, many pigeon pea *(Cajanus cajan* (L.) Millsp.) plants of U.W.I. semi-determinate dwarf cvs. growing at Lawrence Field, St. Catherine, Jamaica, were observed to be suffering from a chlorosis and dieback. These plants had been reaped in late 1969, had been severely defoliated by rust (caused by *Uredo cajani),* but were at the time of the initial observations, producing new leafy shoots. It was these young leaves that were chlorotic. Old bearing shoots were dying at the tips and this dieback apparently progressed down the plant, until the entire plant died. Yellowed and apparently healthy green plants occurred within 0.5 to 1 m of each other. Some dwarf cultivars appeared more susceptible than others. The syndrome was again observed in 1971–72 and 1972–73, and several imported cvs., including some tall indeterminate types, were found to be seriously affected. Many indeterminate types are apparently less susceptible however.

This syndrome has not been seen elsewhere in Jamaica on the same or other cvs, nor has it been reported from those Commonwealth Caribbean territories to which the susceptible U.W.I. dwarf cvs have been sent for trial. The soil at Lawrence Field is a Caymanas Clay Loam derived from recent alluvium. It is well drained with good moisture supplying capacity, highly fertile and alkaline in reaction (Vernon, 1958). Lawrence Field is situated in a low rainfall (750–1000 mm per annum) zone

DEVELOPMENT OF SYMPTOMS

Only new leaves, produced after the plant has borne its first flush of pods, are affected. These are usually much reduced in size, cupped and twisted, but may be more-or-less normal in size and show no distortions. Leaves may be pale green at first becoming uniformly yellow later or may be yellow from the outset. Branches with yellow leaves and branches with apparently normal (green) leaves are occasionally found on the same plant. These green leaves ultimately become yellow and the plant eventually dies. Dieback begins at the tips of the old bearing shoots and progresses downwards until only the basal portion of the main stem is alive, typically bearing a few clumps of small yellow leaves. These leaves shrivel and fall as the dieback progresses. The time from bearing and reaping to death may be 5 to 12 weeks, depending partly on the size of the plant. Recently dead plants are usually easily pulled from the soil, the main structural roots apparently breaking quite easily.

OBSERVATIONS

Symptoms have invariably been seen on rust-infected plants that have suffered severe defoliation. Three cvs showing some rust-resistance have not succumbed to the syndrome, but many rust-susceptible cvs also show resistance to the syndrome. Symptoms do not resemble those of any reported disease, nor has examination of whole still-living plants revealed any "novel" lesions that might indicate a living causal agent. Examination of root (and soil) samples has shown the presence of nematodes on both affected and unaffected plants.

Plotting the incidence of the syndrome within experimental plantings or over larger areas has shown no pattern that could be considered non-random. Within a plot of uniformly spaced plants some may appear healthy while others are severely yellowed. This is partly due to differences in the time and rate of development of symptoms. Water stress appears to hasten the development of symptoms and increase the proportion of affected plants.

EXPERIMENTS AND RESULTS

Soil Analysis.

Soil samples taken in 1971 from below affected plants had a mean pH (1 : 5 soil : water suspension) of 7.4 compared with 7.6 from below unaffected plants or adjacent fallow land. This difference was statistically significant (S.E. = ± 0.025 with 12 d.f.). There were no significant differences in available P_2O_5 or K_2O or in total N.

Soil Bioassay.

Large samples from below affected and unaffected plants and from adjacent fallow land were sieved, and half of each sample autoclaved. No effects of either origin or autoclaving on emergence, appearance or fresh weight at 35 days of either pigeon peas or beans *(Phaseolus vulgaris)* were found. Plants were grown in 6 cm pots with ten replicates. Self-sown pigeon pea plants below severely yellowed or dead plants showed no abnormalities.

Leaf Analysis.

A total of 37 leaf samples have been analysed for Mn and Fe : 23 of these have also been analysed for Zn and 13 for Cu. Leaves were classified as "yellow", "young green" (i.e. new green leaves camparable in age with the yellow leaves), or "old green". They were mainly from U.W.I. dwarf cvs grown at various sites in 1971 and 1972. Leaf lamina only were analysed after careful washing and oven drying. The data are summarised in Table I. Mean Mn, Fe and Zn contents of yellow leaves are respectively about half, seven-eighths and two-thirds those of young green leaves. The mean Cu content is higher in yellow leaves however. Old green leaves, which were badly rust-infected, were similar in mean Mn and Fe contents to young green leaves. Ratios of Mn to Fe+Zn show a marked difference between yellow and green leaves. Taken overall, Mn appears most clearly linked with yellowing, although Fe cannot be entirely ruled out. A Mn content of 65 ppm, and a Mn/Fe+Zn ratio of 0.17, appear to discriminate between yellow and green leaves.

Attempted Induction of Symptoms.

Plants were established in one (U.S.) quart cans containing soil collected from Lawrence Field. Lime or acid was added to batches of soil to give pH's of 8.1 and 4.5 respectively: unamended soil had a pH of 7.4. Plants were induced to flower by artificially shortening the photoperiod. A range of micronutrient, soil drench treatments, with untreated controls, were superimposed. Not one plant showed any yellowing or dieback symptoms.

Correction of Symptoms.

Foliar sprays of soluble or chelated forms of Fe, Zn, Mn, Cu, Co, B and Mg plus various wetting agents, have consistently failed to delay or reverse symptoms. Soil drenches have also failed. Some data from two recent experiments with sprays and drenches are summarised in Tables 2 and 3. In the first, treatments were made to June-sown plants. Five applications were made, weekly, from December 8, 1971. Plants were classified on January 25, 1972, as yellow, pale green or green and leaf samples taken. There were 4-6 plants per plot and two replicates.

A chi-square test showed no significant effect of treatment on the number of yellow, pale green or green plants. Soil drenches did not increase leaf Mn contents (Table 2) relative to the controls, but soil drenches (and foliar fertilizer) did increase leaf Fe. Foliar sprays of Mn and fertilizer increased leaf Mn to very high levels, presumably due to surface adsorption resistant to washing. Differences between yellow and pale or green leaves in Mn and Fe contents were not consistent, and values for yellow leaves were very high, particularly for Mn, compared with those of Table 1.

In the second trial, planted September 7, 1972, a number of pre-bearing treatments were compared with a control and a "post-bearing" foliar spray. Treatments are shown in Table 3: they included urea and $(NH_4)_2SO_4$ as drenches to examine, *inter alia*, the effect of sulphur. There were 25 plants per plot, spaced 46 x 46 cm and three replicates. At 150 days after planting, when plants had borne one crop of pods and were flowering again, over 40% of plants of the control and urea treatments were severely affected, significantly more than with Mn, complete fertilizer or $(NH_4)_2SO_4$ as soil drenches. "Post-bearing"Mn was only slightly better than the control in % severely affected plants. By 190 days all plants receiving the latter treatment were dead or severely affected. The lowest value was with complete fertilizer to the soil. By 205 days, no treatment had less than 75% of plants severely affected, and it is clear that no treatment did more than delay the development of severe symptoms.

Nematicides.

Mr. D. Hutton, Nematologist, Ministry of Agriculture, Jamaica, examined soil samples from beneath pigeon pea plants at Lawrence Field. *Rotylenchulus reniformis* was the major species found: others included *Tylenchorhynchus* sp., *Helicotylenchus* sp. *Scutellonema* sp., *Pratylenchus* sp., *Longidorus* sp., and *Hoplolaimus* sp. Root damage by nematodes is a possible cause of lowered nutrient uptake, so a simple nematicide trial was laid down. Plot size was 1.22 x 6.1 m with 20 plants 30.5 m apart in a single row. There were 4 replicates and treatments are given in Table 4. All nematicide-treated plots received D-D on October 5, 1972. The experiment was planted October 20, and treatments applied January 19, 1973. Pods were harvested from February 12. Two of the treatments significantly increased yields, as number of pods per plant, over the untreated control (Table 4). The distribution of yellowed plants was erratic and unrelated to treatment up to May 16, 1973, when a final assessment was made.

DISCUSSION

Much of the data support the hypothesis that Mn deficiency is at least associated with the syndrome. "Lime induced" chloroses, due to non-availability to the plant of soil Mn and Fe are well known and the Ph of the Lawrence Field soil is sufficiently alkaline to reduce Fe and Mn availability. Foliar sprays are a recognised means of correcting Mn deficiencies so that the failure of spraying to reliably correct symptoms in pigeon pea does not support the hypothesis that Mn deficiency is a primary cause. It is unlikely that the large amounts of leaf Mn recorded in the first spraying trial (from *yellow* leaves) were entirely surface-adsorbed and physiologically non-functional. In the second spraying trial Mn sprays reduced yields without affecting the subsequent development of the syndrome. Soil drenches were scarcely more effective, nor did the "complete" fertilizer materially improve survival and/or recovery, either as foliar spray or drench. This suggests that deficiencies of mineral nutrients were not primary causes of the syndrome. The possibility remains that "low" leaf Mn (i.e. below c 65 ppm) is merely associated with, and not a primary cause of, the yellowing syndrome.

Little is known of the mineral nutrition of *Cajanus cajan*. Nichols (1965) studied the effects of major element deficiencies on growth, nodulation and mineral content, and also described and illustrated the major deficiency symptoms (Nichols 1964). His experiments did not examine the effect of Mn, nor did his analytical data include this element. His data for leaf-Fe in 13-week old nodulated plants, give 126 ppm with complete nutrients (in sand culture) – a value below the presently reported median ranges – and 61 ppm when Fe was absent. This latter is similar to the minimum value found in the present work.

It would be premature to comment on the role of nematodes in the syndrome. Ayala (1962) and Ayala & Ramirez (1964) have reported on the nematode species found on pigeon pea roots in Puerto Rico. In view of the wide host range of *Rotylenchulus reniformis* and its importance, further studies on this and the other species recorded by Mr. Hutton, appear necessary. Work is already in progress and planned for the future. Two nematicide treatments increased yields, which were in any case very low, but none prevented yellowing and dieback symptoms developing. Association of nematodes with this syndrome is therefore unproven. More work with nematicides is planned, to ascertain further their effects on yield and the role of nematodes in yellowing.

There are many odd features to the occurrence of the syndrome that cannot be readily explained: the spatial distribution and the absence of any symptoms, apparently regardless of planting date, prior to bearing. Pre-bearing crops are normally well watered whereas post-bearing plants tend to receive less regular watering. There are also several possible causes that remain unexplored or incompletely tested. Soil borne diseases (and diseases in general), changes in the root system and nodules coincident with the end of the initial bearing, changes in mineral nutrient availability with change in wetting-drying cycles in the soil, are all topics that merit investigation in addition to the topics already under study.

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Table 1

Mn, Fe, Zn and Cu contents (ppm in lamina dry-matter) and the Mn/Fe+Zn ratio of pigeon pea leaves. Leaves were classified as yellow, young green or old green. Means, ranges and median 50% ranges are given.

Leaf type	No. of samples	Mean	Range	Median 50% range
		Manganese (Mn)		
Yellow	15	48	12–76	40–63
Young green	15	93	50–165	80–111
Old green	7	92	55–165	65–109
		Iron (Fe)		
Yellow	15	210	82–325	185–225
Young green	15	246	59–375	200–289
Old green	7	246	140–350	193–300
		Zinc (Zn)		
Yellow	8	40	5–95	19–50
Young green	10	60	21–146	45–58
Old green	5	37	9–50	35–40
		Copper (Cu)		
Yellow	7	23	13–68	13–17
Young green	6	13	5–17	10–15
		Ratio Mn/Fe+Zn		
Yellow	8	0.15	0.10–0.26	0.13–0.16
Young green	10	0.26	0.14–0.49	0.21–0.26
Old green	5	0.28	0.18–0.41	0.20–0.31

Table 2

Mn and Fe contents (ppm in lamina dry-matter) and the Mn/Fe+Zn ratio of pigeon pea leaves as affected by various foliar and soil treatments. Plants (and leaves) were classified as yellow (Y), pale green (P) or green (G). Values in parentheses are weighted) means for treatments. (Cv. CH 11/33/34).

Treatment	Mn (ppm)			Fe (ppm)			Mn/Fe+Zn		
	Y	P	G	Y	P	G	Y	P	G
Mn[1] – foliar	1216	1300 (1263)		180	197 (189)		*	4.32 (4.32)*	
Mn[1] – soil	82	(109)	144	254	(254)	255	0.19	(0.19)*	0.19*
Fert.[2] – foliar	395	(362)	317	217	(228)	199	*	(0.97)*	0.97*
Fert.[2] – soil	95	83 (106)	253	170	262 (231)	259	0.33	0.20 (0.29)	0.64
Water – foliar		309 (267)	161		168 (171)	180		0.96 (0.83)	0.50
Water – soil	110	(133)	149	304	(282)	266	0.24	(0.34)	0.42

*value missing or based on imcomplete data

[1] $MnSO_4$ $4H_2O$ at 0.33% wt/vol. plus Citowett as foliar spray to run-off, or 6.6g in 2 litres per plant as a soil drench.

[2] Soluble fertilizer (32%N, 12%P_2O_5, 12%K_2O, 6%S, 1%CaO, 3%MgO, 1500 ppm Mn, 850 ppm Fe, 600 ppm Cu, 525 ppm Zn, 120 ppm B and 15 ppm Mo) at 0.66% wt/vol. plus Citowett as foliar spray to run off, or 13.3 g in 2 litres per plant as a soil drench.

Table 3

Effect of treatments on percentage of severely affected plants at 150, 190 and 205 days from sowing. Figures in parentheses are angular transformed values, to which S.E.'s apply. (Cv. CH 11/33/34)

	Percent severely affected plants at		
	150 days	190 days	205 days
Mn[1] – foliar*	21 (27.4 a[4])	60 (50.9 ab[4])	87 (69.1 ab[4])
Mn[1] – soil*	23 (28.5 a)	43 (41.2 ab)	82 (65.0 ab)
Fert.[2] – foliar*	32 (34.5 ab)	72 (58.4 c)	97 (80.8 bc)
Fert.[2] – soil*	24 (29.5 a)	38 (38.0 a)	75 (60.2 a)
Untreated control	44 (41.4 b)	67 (55.0 bc)	95 (78.1 bc)
Mn[1] –– Post–bearing**	37 (37.7 ab)	100 (90.0 d)	100 (90.0 c)
$(NH_4)_2SO_4$[3] – soil*	26 (30.8 a)	45 (42.1 ab)	80 (63.3 ab)
Urea[3] – soil*	48 (43.9 b)	54 (47.5 ab)	93 (74.9 abc)
S.E. (14 d.f.)	(2.14)	(3.35)	(3.40)

[1] $MnSO_4\ 4H_2O$ at 0.5% wt/vol plus "Citowett" as foliar spray to run-off, or 2.2 Kg/ha per application as soil drench.

[2] Soluble fertilizer (20%N, 20%P_2O_5, 20% K_2O, 420 ppm MgO, 780 ppm Mn, 290 ppm B, 255 ppm Mo, 64 ppm Cu, 51 ppm Fe, 46 ppm Zn) at 6.25% wt/vol plus Citowett as foliar spray to run-off, or 55 kg/ha per application as soil drench.

[3] To give 22.5 kg/ha N per application as a soil drench.

[4] Means with the same letter do not differ significantly by Tukey's test.

*Treatments applied "pre-bearing"; 5 applications, weekly, from October 24, 1972 (47 days after planting.)

**Foliar spray; 5 applications between January 22 and February 14, 1973 (137 to 160 days from planting).

Table 4

Effect of nematicide treatments on yield of pigeon peas, as pods per plant from 4 pickings over 35 days beginning February 12, 1973. (Cv. CH 11/33/34).

	Untreated control	Nematicide treatment[1, 2]			
		Nemagon	Nemacur	Vydate	Furadan
Yield: pods per plant (± 0.43)	7.2 a[3]	9.1 ab	7.9 a	10.3 b	10.6 b

[1] All nematicide-treated plots received preplant 'D–D' (dichloropropane – dichloropropene mixture) at 445 l/ha on October 5, 1972.

[2] 'Nemagon' (dibromochloropropane) at 16 kg/ha a.i.

'Nemacur 'P' (O–ethyl O–(3–methyl–4–methylthiophenyl) isopropylamidophosphate) at 18.0 kg/ha a.i.

'Vydate L' (methl N', N–dimethyl–N– [(methylcarbamoyl) oxy]–1–thiooxamimidate) at 2500 ppm as foliar spray.

'Furadan' (2, 3–dihydro–2, 2–dimethyl–7–benzofuranyl methylcarbamate) at 13.4 kg/ha a.i. All applied January 19, 1973.

[3] Means with the same letter do not differ significantly by Tukey's test.