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The importance of lower pods in the control of the cocoa Phytophthora pod rot

Resumen. El presente estudio revela que las primeras mazorcas de cacao infectadas por *Phytopthora palmivora* son aquellas más cercanas al pie del árbol. Este hecho parece confirmar que el suelo representa la principal fuente de inóculo. Sin embargo, se encontró que el primer metro del árbol desde la base contribuye hasta en un 31.0% de la producción anual de mazorcas de las cuales se pierden verdes solamente un 4.2% de la producción total del árbol. Los bajos niveles de pérdida total de mazorcas no justifican la recomendación de suprimir o remover todas las flores en el metro del árbol más cercano al suelo, como medida de control de esta enfermedad.

The soil is known to be the major source of inoculum of the Phytophthora pod rot disease of cocoa at the onset of the season (13, 12, 9). Okaisabor (10) tried to suppress the soil phase of the pathogen by soil drench. Regular application of insecticides is also thought to be a useful proposition in controlling those insects which carry propagules along with the soil which they use in building tents and some other insects which act as vectors for the spread of the disease (3, 11). Okaisabor (7) showed that by removing the lower pods from the base to a height of three feet it was possible to reduce the overall loss in the plot. Maddison (4) believes that the use of flower suppressing agents to reduce the number of flowers at the basal region of the stem is likely to be more acceptable to farmers than pod removal, both of which are designed to ensure that there are no pods near the soil on to which rain-splash can disperse the spores *of Phytophthora palmivora* (Butl.) Butl. It thus appears that the removal of basal pods is an important factor and merits serious consideration in devising control measures for the disease. The question which the present investigation sets out to answer is whether removal or suppression of all pods at the base of trees is a worthwhile consideration judging from the number of pods that are infected as against those removed or suppressed.

Experimental

Fifty cocoa trees were selected in each of plots N3/2, N3/4 and N4/2B at the Gambari Experimental Station, Ibadan. The cacao in N4/2B are F3 Amazon planted during the 1963/64 season. Those in N3/4 were of the WACRI 1945 Progeny Trial II, while the trees in plot N3/2 are ICSI clonal planting of 1951. Each selected tree was marked at one metre intervals from soil level upwards. Records of healthy and *P. palmivora* infected pods were taken at fortnightly intervals between January and December. 1976. Routine farm operations which included regular harvesting of ripe and diseased pods, fungicide and insecticide sprayings were carried out in the plots.

Results

The production pattern of the cocoa trees in the plots is such that a large proportion of the pods are borne on the tree trunks. Although some of the trees are fairly tall, especially some of those in plot N3/4, the canopy is reached at or slightly above the 4 metre level in most of the experimental trees.

The first infections in N3/2 were observed on two pods which were 0-1 m above the soil; one each on two trees on 27th April. After the removal of those diseased pods, no new infections were ob-

served in the whole plot for another three months when the first infections on another tree were observed on three immature pods; one each at 0-1, 1-2 and 2-3 m above soil. Further observations during the experimental period showed that a number of first infections started on some trees at 2-3 and even 3-4 m above the soil. Four of such infections were definitely identified as originating from flower cushions. The first infections in N4/2B were observed on 26th May on three trees, each with one diseased pod at 0-1 m above the soil. Infections started on a number of trees at 1-2 and 2-3 m above the soil later in the year. Many of such infections were not immediately traceable to the soil, although one can't rule out the possibility of their being secondary infections from diseased pods for which soil was the primary source of inoculum. The disease started rather late in N3/4 where the first infected pod was observed just above the soil level on a tree (T49) on 7th July. No new infections were observed in the plot between 7th July and 20th August when the first infections on a few other trees were observed at various height levels.

Table 1 shows that more pods were produced within the first metre from soil level than at any other height level excepting N3/2 in which pod production was slightly higher at 1-2 m than at 0-1 m above the soil level.

Incidence of Phytophthora pod rot was highest in N3/2 (3.4% p.a.) and lowest in N3/4 (2.6% p.a.). While 4.2% of the on-tree pods within the first metre above the soil in N3/2 were infected, only 2.2% of those at 3-4 m above soil were infected. Similarly 3.9% of the on-tree pods within the first metre above soil were infected in N3/4 as against 1.9% that were infected at 3-4 m. In N4/2B, 4.4% of the on-tree pods at 0.1 m above the soil were infected, but only 1.6% of those at 3-4 m were infected.

Table 2 shows that there were more pods on the trees in N3/2 between July and December (66.2%) than within the first half of the year (33.8%). Similarly 55.3% of the on-tree pods in N3/4 were recorded between July and December as against 44.7% between January and June. The corresponding figures for N4/2B were 41.3 and 58.7%. Between July and December 35.3% of the on-tree pods in N4/2B were within the first metre above the soil level. A greater proportion, 65.7 and 68.2% of the on-tree pods between July and December in N3/4 and N3/2 respectively were within the first metre above the soil level. In N3/2 4.9% of the on-tree pods found at 0-1 m above the soil between July and December were infected. The corresponding figures were 5.0, 4.4 and 3.2% at the 1-2, 2-3 and 3-4 m levels respectively. Similarly 5.9% of the on-tree pods in N3/4 at 0-1 m above the soil between July and December were infected as against 3.9, 1.5 and 3.7% at 1-2, 2-3 and 3-4 m levels respectively. Disease incidence in N4/2B within the same period were 8.4, 4.6, 3.0 and 3.3% at the 0-1, 1-2, 2-3 and 3-4 m levels respectively.

Table 1. On-tree pods at various height levels (January – December 1976).

Plot	Type of pods	Height in metres				Total
		0 – 1	1 – 2	2 – 3	3 – 4	
N 3/2	Healthy + Diseased	2 368	2 406	2 312	1 846	8 932
	(%)	26 5	26 9	25 9	20 7	
	P. palmivora infected	100	89	78	41	308(3 4)**
	%*	4 2	3 2	3 4	2 2	
N 3/4	Healthy + Diseased	2 076	1 825	1 495	1 090	6 486
	(%)	32 0	28 1	23 0	16 8	
	P. palmivora infected	80	36	34	21	171(2.6)**
	%*	3 9	2 0	2 3	1 9	
N 4/2B	Healthy + Diseased	1 995	1 613	1 016	702	5 326
	(%)	37 4	30 3	19 1	15 2	
	P. palmivora infected	88	41	15	11	155(2.9)**
	%*	4 4	2 5	1 5	1 6	

(%) Denotes percentage of total annual on-tree pods.

%* Denotes percentage of total on-tree pods at that height level

( )** Denotes percentage annual disease incidence in that plot

Table 2. On-tree pods at various height levels (July-December 1976).

Plot	Type of pods	Height in metres				Total
		0 – 1	1 – 2	2 – 3	3 – 1	
N 3/2	Healthy + Diseased	1 616	1 588	1 512	1 199	5 915
	(%)	68.2	66 0	65 4	64.9	
	P. palmivora infected	80	79	66	38	263(4 4)**
	%*	4.9	5 0	4 4	3 2	
	(%)	3 3	3.2	2 9	2.1	
N 3/4	Healthy + Diseased	1 365	912	749	566	3 592
	(%)	65 7	50.0	50 1	51.9	
	P. palmivora infected	80	36	34	21	169(4.7)**
	%*	5.9	3 9	4.5	3.7	
	(%)	3 9	2.0	2 3	1 9	
N 4/2B	Healthy + Diseased	704	711	460	329	2 204
	(%)	35.3	44.1	45.3	46.8	
	P. palmivora infected	59	33	14	11	117(5 3)**
	%*	8.4	4 6	3 0	3.3	
	(%)	3.0	2 0	1.4	1.6	

(%) Denotes percentage of annual on-tree pods (see Table 1) at that height level

%* Denotes percentage of total on-tree pods at that height level between July and December

( )** Denotes percentage disease incidence in that plot for the period.

Discussion

Slightly less than a third (30.5%) of the annual on-tree pods in the three plots were produced within the first metre above soil. The fact that 57.2% of them are on the tree between July and December, while the first infections were observed between April and July, tends to suggest that a large proportion of the pods were on the trees at a time when weather conditions were favourable for the initiation and spread of the *Phytophthora* pod rot disease. This situation is confirmed by the results which showed that incidence of the disease was higher at comparable height levels in all the plots within the second than the first half of the year. This is to be expected since the second half falls within the peak of the rainy season and the initiation and spread of the disease is favoured by high relative humidity (8). Results in Tables 1 and 2 show that the annual incidence is rather low in all the plots. This is perhaps due to the fact that the figures were calculated on the basis of on-tree pods rather than harvested pods. The results also tend to show that the incidence of the disease appears to decrease with increase in the height of the pods from soil level. This confirms previous reports that the disease starts on pods at ground level and spreads up the tree (7). The fact that the first infections in a number of trees were traced to cushion infections suggests however that a few primary infections must have originated from sources other than the soil. Mummified pods (1, 5), flower cushion infections (5, 6) and stem cankers (2) have been reported to be sources of primary infections. Similarly, invertebrates including ants have been reported to serve as vectors for the spread of spores of *Phytophthora palmivora* (3).

Loss of all the 100 infected pods within the first metre above soil in N3/2 does not appear to justify the removal or suppression of all the 2368 pods produced at that height level as the incidence level is only 4.2%. The same is true of plots N3/4 and N4/2B where the annual disease incidences are 3.9 and 4.4% respectively. Even if one were to limit basal pod removal or suppression of flowering to only the disease epidemics period (July-December), as much as 68.2% of all on-tree pods in N3/2 at that height level, which is 26.5% of the annual on-tree pods, would have been lost in an attempt to prevent an annual incidence of 3.4%. Similarly 65.7 and 35.3% of the on-tree pods at 0-1 m, which will be 32.0 and 37.4% of the annual on-tree pods at 0-1 m in plots N3/4 and N4/2B respectively, would have been sacrificed in an attempt to prevent annual disease incidence of 2.6 and 2.9% respectively. It appears therefore that, excepting in cases where disease incidence is known to be extremely high, neither the removal of all basal pods nor the suppression of flowers at the basal level should be

carried out solely as a disease control measure. Other methods which might include special fungicide and insecticide sprays, plot sanitation and even soil drenches could be more worthwhile propositions.

Summary

This investigation shows that first infections by *Phytophthora palmivora* are usually found among cocoa pods lower down the tree trunks. This appears to confirm the role of soil as a major source of inoculum. It was found however, that the first metre up the tree trunk accounts for as much as 31.0% of the annual pod production as against an overall whole tree annual pod loss of only 4.2%. Such a low level of total pod loss does not justify the recommendation of suppression or removal of all flowers within the first metre of each tree as a control measure.

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