Reaction of cocoa seedlings to artificial inoculation of *Phytophthora palmivora*

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The difficulty of finding adequately resistant cocoa varieties to start with seems to have played down the importance of this reality. Problems facing workers breeding for black pod resistance are many, but perhaps the most important of these is locating suitable sources of resistance. Lack of uniformity in F_1 progeny of crosses between cocoa varieties that have shown field resistance has been reported (J. D. AMPONSAH, 1971). AMPONSAH and ASARE-NYAKO (in press) reported a laboratory method for screening large quantities of seedling material to eliminate susceptible seedlings at an early stage leaving only resistant ones for field planting. This paper describes cocoa seedling reaction to artificial inoculation with *P. palmivora.*

MATERIALS AND METHODS

The cocoa varieties used in this experiment involve a wide range of selections that are being tested in the black pod resistance screening programme at Tafo. They include types that have consistently shown low field susceptibility to black pod infection at Tafo or elsewhere. The selection T79/501 a resistant type, is from the population of seedlings resulting from the cross Na 32 × Pa 7 introduced from Trinidad by Posnette (1945). Y44 also resistant intermediate and U6 are local selections from the Anyinam and the Suhum areas respectively and Scavina 6 is one of Pound's introductions to Trinidad from the Upper Amazon (POUND, 1938) types and has been considered resistant in Trinidad. Known to be highly susceptible are Na 32, also from Pound's introductions and A12, a local selection from the Aburi area. Gs 29, selection from Greneda, and N5/131 an introduced clone labelled IMC 60, which is probably incorrect are susceptible i.e. above average susceptibility.

Other selections included for various reasons are the local Amelonado cocoa originally introduced from Fernando Po. S27 and Acu 85 both local selections from the Asuansi and the Aburi areas respectively.

Seeds of the required crosses were obtained by hand pollination. The preparation of the seeds for artificial inoculation has been described, AMPONSAH and ASARE-NYAKO (in press). Seeds pregerminated for four days were submerged in the fungus inoculum for three minutes and the seeds planted immediately in well watered sterilized soil in seed boxes arranged on greenhouse benches. The inoculated seeds were watered every morning and observed for their reaction to inoculation.

RESULTS AND DISCUSSION

Table 1 illustrates the differential susceptibility of seedlings of different parentage. Crosses between resistant varieties tend to have lower percentages of susceptible seedlings than progenies of susceptible parents. Progenies of susceptible and resistant parents give larger proportions of susceptible seedlings than progenies of two resistant parents.

Seedling reactions range from death to apparent non-infection. Apparently uninfected seedlings on close examination may show mild infections on roots, stems or hypocotyl which became healed at very early stage. *P. palmivora* has been re-isolated from such seedlings. Despite the presence of the fungus such seedlings have grown normally and have not developed after being kept in the nursery for over two years. Such seedlings are considered « resistant » but their fate at longer periods in the field as well as the level of pod infection compared with unscreened seedlings of the same types are yet to be ascertained.

PRE-EMERGENCE DEATHS. NON EMERGENCE

Seedlings are said to have emerged when the cotyledons are raised clear of the soil. Non-emerged seedlings thus include :

(*a*) Seeds which completely fail to germinate. The plumule does not emerge and the seed remains embedded in the soil. The cotyledons in such cases tend to remain fresh for considerable periods (8 weeks) in the soil. The radicle and hypocotyl are rotted away as also is the plumule.

(*b*) The radicle and hypocotyl get rotted but the plumule emerges. Rootlets appear at the base of the plumule but development of such a root system never becomes extensive and seedlings remain stunted.

TABLE 1

THE REACTION OF PREGERMINATED COCOA SEEDLINGS TO INOCULATION WITH *PHYTOPHTHORA PALMIVORA* BUTL.

Parents	Known field reaction	No. of pregerminated seeds planted		Percentage emerged after 10 days		Percentage healthy seedlings after 2 months		Percentage susceptible	No. of separate tests
		Inoc.	Uninoc.	Inoc.	Uninoc.	Inoc.	Uninoc.		
Na 32 × Y44	S × R	280	80	41.1	98.8	21.1 (21.3)	100.0	78.7	3
" × K5	S × Int.	500	100	35.2	100.0	26.6 (26.6)	100.0	73.4	5
" × Sca 6	S × R	160	40	23.8	97.5	20.0 (20.2)	99.2	79.8	2
" × P 30	S × Int.	280	96	28.6	100.0	18.9 (18.9)	100.0	81.1	4
" × Lafi 7	S × ?R	460	120	29.3	99.2	15.9 (16.0)	99.2	84.1	5
" × N8/131	S × S	467	104	29.6	96.2	15.8 (16.4)	96.2	84.2	6
" × GS 29	S × S	1 011	260	27.8	96.5	15.2 (16.3)	93.5	84.8	12
T79/501 × K5	R × Int.	500	140	54.4	100.0	47.2 (47.2)	100.0	52.8	6
" × P 30	R × Int.	739	120	67.5	95.0	45.7 (50.3)	90.8	54.3	6
" × Y44	R × R	338	120	60.1	96.7	45.3 (46.1)	98.3	54.7	4
" × Sca 6	R × R	1 079	256	59.4	99.2	43.9 (47.8)	91.8	56.1	11
" × GS 29	R × S	720	160	47.2	99.4	41.7 (42.0)	99.4	58.3	8
" × Na 32	R × S	400	120	41.3	100.0	22.0 (22.0)	100.0	88.0	4

( ) Adjusted proportion for deaths shown in the uninoculated seedlings.

POST-EMERGENCE DEATHS

Damping off

Less than 5% of post-emergence deaths could be attributed to damping-off. This is contrary to the impression given by the extension officers who call all seedling deaths damping-off.

Root rot

This accounted for about 15% of post-emergence deaths of seedlings and occurred in young as well as in older (over a year-old) seedlings. It resulted in stunting where a few roots were free of infection or in wilting or collapse of seedlings where the rot was extensive. The effect is dramatic in young succulent seedlings which tend to droop ; the stem bending so that the cotyledon rests on the soil. In older seedlings, the loss of turger and drooping in green leaves is the first sign of the wilt.

Hypocotyl and stem infections

Infection at these sites may be limited to one side only ; in which case the plant bends towards the side with the lesion. When the infection spreads laterally wilt of the seedling above the infection site occurs. When the cotyledon is involved, this means death of the seedling but where the stem is involved, the axillary buds at the junction of the cotyledon and the stem sprout to replace the dead stem. These stems also bear two axillary buds each which in turn may replace the stems if these get killed also.

Cotyledon infection

Infection at this site tends to be invidious. The fungus invades the stem at the cotyledon junction, killing the axillary buds in the process. When only one cotyledon is infected, the stem lesion may develop on the side of the infected cotyledon and spread upwards and downwards. The stem bends towards the site of the lesion but the plant may not die unless lateral spread of infection occurs. Where both cotyledons are infected, both axillary buds tend to be destroyed and the lesion girdles the stem thus killing the plant. Another interesting development in cotyledon infection is the tendency in older stems for the fungus to invade the pith primarily through the ray parenchyma. Viable inoculum have been isolated from the pith of Na 32 × A12 seedlings 18 months after inoculation. In the pith spread tends to be upwards and downwards. Infected cotyledons tend to be persistant. There is a tendency for plants to break at the junction of cotyledons and stem when infection has invaded the pith.

RESISTANCE REACTIONS

Healing of lesions may occur in both« resistant » and « susceptible» seedling progenies. When a new cambium is formed beneath the lesion, the bark tends to be restored at the infection site. In other cases, the cambium formation is not complete ; the lesion spread is checked but the wood — stele — at the infected site becomes exposed. Various gradations of this incomplete healing may occur and may result in extreme cases in conspicuous exposed stellar tissue or the formation of a slit in the bark.

When the tap root is lost through infection, the plant may replace it by two, rarely three roots which grow downwards. In other cases, the tap root is not replaced but numerous lateral or feeding roots are produced. The plants in the latter case look vigorous but lodge readily.

The healing of wounds on stems and on the hypocotyl may result in the formation of pits in the stele. This may be accompanied by thickening of the bark although thickened bark in the hypocotyl region of infected plants may show no stem pittings.

CONCLUSION

It may be said that resistance occurs in progenies of « susceptible » and « resistant » varieties. Both field and gauzehouse observations agree on this phenomenon. Resistance or ability to survive and ward off infection appears to depend on protoplasmic reactions and the regeneration of tissues following the formation of cambium in infection areas. Wounds could heal over viable inoculum.