# IMPACT OF ROOT (WILT) DISEASE ON THE YIELD OF YOUNG COCONUT PALMS

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**ABSTRACT**

When young West Coast Tall palms under regular fertiliser management contracted the disease during the pre-bearing period, the onset of bearing was found to be delayed. While about 90 per cent of the healthy palms flowered by the end of the eighth year, it was only around 70 per cent in palms which contracted disease during the pre-bearing stage. About 18 per cent of these diseased palms did not flower even up to the thirteenth year. Decline in yield was faster in palms which became diseased in later years. In general, about 45 per cent decline in yield was observed in diseased palms, during the course of 10 years, compared to the yield of healthy palms, while in palms which were diseased during the initial years, this loss was to the extent of 68 per cent.

In Dwarf × Tall palms though the occurrence of disease was at a slower rate the increase in the disease index was higher compared to that in WCT palms. The diseased Dwarf × Tall palms, in general were giving about 60 per cent lower yields, compared to the healthy palms.

## INTRODUCTION

In the past, many attempts have been made to study the impact of root (wilt) disease on the yield of coconuts. Ramadasan *et al.* (1971) have observed that in palms which contracted the disease before the commencement of bearing, flowering was often delayed indefinitely and the yield of such palms was also drastically affected. Jose Abraham *et al.* (1987) reported significant negative correlation between yield and intensity of disease (disease index). They also reported an average reduction of 0.5 nut per index value, under cultivators' conditions, while it was 1.3 nuts per index for the younger palms under well managed farm conditions. The impact of root (wilt) disease on the time taken for flowering, trends in yield during the initial years of bearing for healthy and

diseased palms, the regression between disease intensity and yield and the loss in yield in two fertiliser trials conducted at CPCRI Regional Station, Kayangulam are presented.

## MATERIALS AND METHODS

Two fertiliser trials were conducted at CPCRI Regional Station, Kayangulam, Kerala in soils of loamy sand type, under rainfed condition, receiving regular plant protection measures and cultural operations. Experiment No. 1 was initiated in 1970 on 648 newly planted West Coast Tall seedlings, to study the effect of N, P, K, Ca and Mg on the root (wilt) disease of coconut. The design adopted was split-plot, with 27 main plot treatments as the factorial combinations of three levels each N, P and K, in 24-tree plots, in a $3^3$ confounded factorial arrangement, and the subplot treatments as factorial combinations of two levels each of Ca and Mg. Experiment No. 2 was laid out in 1972 using 324 newly planted D × T hybrid seedlings, to study the performance of these hybrids in root (wilt) disease affected area, under different fertiliser levels. There were 18 treatments, consisting of three levels of NPK × two levels of Ca × three levels of Mg.

Observations on the time taken for flowering, flowering leaf axil number (for Experiment No. 1 only), incidence of disease and its intensity, yield of nuts etc., recorded regularly were utilised for this study. The intensity of disease was measured using the method suggested by George and Radha (1973).

The palms which contracted disease in different years were considered separately to study the impact of the disease on the time taken for flowering. While studying the trend in yield for the initial years, the data for 1984 were omitted, in view of the fact that the same was adversely affected by the unprecedented drought of 1983. Both linear and quadratic models were tried, to work out the relationship between the age of the palm and the yield. The loss in yield due to the initiation of disease in different years was also worked out for the cumulative yield data for the tenth, twelfth and the fourteenth years. The relationship between disease intensity and yield was studied, by grouping the palms based on the intensity, and fitting linear regression models.

In Experiment No. 1, replanted seedlings have been excluded for recording flowering behaviour and yield was recorded in only 534 palms which had survived till the end of 1984. Similarly, in the case of D × T palms, 315 have been considered for flowering details, and 310 for yield studies, out of a total of 324 seedlings planted.

## RESULTS AND DISCUSSIONS

### a) Flowering in Relation to Initiation of Disease

Symptoms of root (wilt) disease were visible from the fourth year of planting, in both West Coast Tall (WCT) and D × T palms. By the end of the twelfth year, 62 per cent of the West Coast Tall palms and 39 per cent of the D × T palms had contracted disease. Cumulative figures for the percentage of

palms which came to flowering and palms which contracted disease in different years are presented in Table 78.1. In the case of West Coast Tall palms, flowering started by the fifth year while in D × T palms, flowering was earlier and 87 per cent had come to flowering by the fifth year. All the D × T palms had flowered by the eighth year, whereas it was only 90 per cent in West Coast Tall. Treatment with Mg was found to slightly favour early flowering. At the same time, the incidence of disease was also more in Mg treated palms.

**Table 78.1:** Progress in flowering and initiation of disease in West Coast Tall (planted: 1970) and D × T (planted: 1972)—cumulative percentage figures

| *Age of the palm (years)* | *Flowering* | | *Initiation of disease* | |
|---|---|---|---|---|
| | *WCT (n = 633)* | *D × T (n = 315)* | *WCT (n = 633)* | *D × T (n = 315)* |
| 3 | – | 7.6 | – | – |
| 4 | – | 61.9 | 2.8 | 1.9 |
| 5 | 11.1 | 87.0 | 4.4 | 2.9 |
| 6 | 45.7 | 92.7 | 9.0 | 4.1 |
| 7 | 79.0 | 95.2 | 22.7 | 4.1 |
| 8 | 90.4 | 100.0 | 27.5 | 7.0 |
| 9 | 95.1 | – | 34.8 | 19.7 |
| 10 | 96.8 | – | 41.7 | 21.0 |
| 11 | 97.8 | – | 49.9 | 39.0 |
| 12 | 97.9 | – | 62.1 | 39.4 |
| 13 | 97.9 | – | 69.7 | – |

In West Coast Tall palms, the percentage of palms which flowered till the end of the sixth year, did not differ significantly between healthy and diseased palms. The delay in flowering was conspicuous in the latter years only.

In general, flowering was found to be delayed, when palms contracted the disease during the pre-bearing period. Ramadasan *et al.* (1971) had also reported similar results. According to Cecil *et al.* (1984) when young palm contracted the disease before flowering, the onset of bearing was delayed by about 12 months.

**b) Occurrence of Disease and its Intensity Over the Years**

Both West Coast Tall and D × T palms started showing symptoms of disease from the fourth year onwards (Table 78.2). By the end of the thirteenth year, nearly 70 per cent of the West Coast Tall palms had contracted the disease. In the case of D × T, 39 per cent of the palms were diseased by the twelfth year. A clear linear trend was visible in the cumulative percentage of palms diseased at different years. Regression studies showed that during this period, every year, 7.7 per cent of the West Coast Tall palms and 5.1 per cent of the D × T palms were diseased, under the prevailing management conditions.

Increase in intensity of the disease index in palms which contracted disease during different years is given in Table 78.3. Regression analysis

**Table 78.2:** Increase in the intensity of disease index in palms which contracted disease during different years

| *Variety* | *Age (years) at initiation of disease* | *No. of palms* | *Mean disease index* | | *Regression of disease index on age* | $R^2$ |
|---|---|---|---|---|---|---|
| | | | *1 year* | *1984* | | |
| WCT | 4 | 16 | 27.2 | 43.3 | 1.32** | 0.71 |
| | 5 | 7 | 25.9 | 41.1 | 1.32** | 0.59 |
| | 6 | 24 | 25.1 | 38.5 | 1.17** | 0.46 |
| | 7 | 52 | 20.2 | 36.2 | 1.56** | 0.53 |
| | 8 | 20 | 30.3 | 33.7 | 1.20** | 0.64 |
| D x T | 4 | 5 | 16.0 | 33.2 | 1.86** | 0.92 |
| | 5 | 2 | 21.7 | 32.3 | 1.54** | 0.98 |
| | 6 | 3 | 22.7 | 33.1 | 1.13** | 0.61 |

**Significant at P = 0.01.

**Table 78.3:** Yield curves for initial years of bearing (1976 to 1983)

| *Age (years) at initiation of disease* | *Mg treat-ment* | $Y = a + bx$ | | | $Y = a + bx + cx^2$ | | | |
|---|---|---|---|---|---|---|---|---|
| | | *a* | *b* | $R^2$ | *a* | *b* | *c* | $R^2$ |
| a) WCT | | | | | | | | |
| 3, 4, 5 | 0 | −28.8 | 4.22** | 0.89 | −8.3 | −0.37 | 0.24 | 0.91 |
| | 1 | −21.0 | 5.40** | 0.66 | −96.6 | 22.31 | −0.89 | 0.74 |
| | P | −25.3 | 4.73** | 0.85 | −46.6 | 9.48 | −0.25 | 0.86 |
| 6, 7 | 0 | −19.5 | 3.99** | 0.89 | −58.9 | 12.81** | −0.46 | 0.94 |
| | 1 | −21.7 | 5.36** | 0.79 | −109.6 | 25.02** | −1.03 | 0.90 |
| | P | −20.7 | 4.80** | 0.83 | −89.1 | 20.09** | −0.80 | 0.92 |
| 8, 9, 10 | 0 | −16.2 | 4.08** | 0.60 | −142.4 | 32.28** | −1.48** | 0.91 |
| | 1 | 1.3 | 3.24 | 0.26 | −197.8 | 47.77** | −2.34** | 0.80 |
| | P | −7.6 | 3.68 | 0.43 | −169.7 | 39.90** | −1.91 | 0.88 |
| 11, 12, 13 | 0 | −44.6 | 8.95** | 0.79 | −201.6 | 44.05** | −1.85** | 0.92 |
| | 1 | −23.9 | 8.34** | 0.55 | −333.1 | 77.44** | −3.64** | 0.96 |
| | P | −35.2 | 8.67 | 0.69 | −260.7 | 59.06** | −2.65** | 0.94 |
| Healthy | 0 | −56.2 | 10.25** | 0.90 | −151.3 | 31.60** | −1.12 | 0.95 |
| | 1 | −51.7 | 12.07** | 0.82 | −250.8 | 56.57** | −2.34** | 0.94 |
| | P | −53.9 | 11.23** | 0.87 | −202.7 | 44.47** | −1.75** | 0.96 |
| b) D x T | | | | | | | | |
| 4, 5, 6 | | −4.2 | 2.27 | 0.20 | 30.4 | 7.92 | 0.68 | 0.27 |
| 8 | | 53.0 | −1.09 | 0.01 | −57.3 | 31.31 | −2.16 | 0.13 |
| 9 | | 61.2 | 0.54 | 0.001 | −309.5 | 109.60 | −7.27 | 0.78 |
| 11 | | 27.1 | 5.58 | 0.19 | −202.8 | 73.23 | −4.51 | 0.65 |
| Healthy | | −8.2 | 12.55 | 0.56 | −180.8 | 63.38 | −3.39 | 0.73 |

**Significant at P = 0.01.
$x$ : age (years) after field planting.
Mg treatment — O: $Mg_0$; 1:$Mg_1$.
Y : expected yield at age $x$.
P = Pooled.

showed that the increase in the disease score was linear, and the rate of increase was found to be about 1.3 points every year. In the case of D × T palms, the initial score was found to be slightly less at 20 points only, but was later increasing at the rate of 1.5 to 1.8 points every year. The marginal differences observed for the regression coefficients (rate of increase) were perhaps due to the varying number of years for which the data have been considered.

**c) Trend in the Yield During the Initial Years**

The tall variety of coconut palm normally begins to bear in five- to seven-years after planting and thereafter it takes another five- to six-years to reach the stage of full productivity (Menon and Pandalai, 1958). In this study, the yield data for the first 13 years after field planting alone have been considered for West Coast Tall and 11 years for D × T palms. During this period, the yield of palms is expected to show a rising trend. In the linear regression model $y = a + bx$, the coefficient of x ("b") measures the slope of the line or the growth rate. In healthy West Coast Tall palms, the yield of nuts was increasing at the rate of 11.2 nuts per palm per year, during the period under reference, whereas in palms which contracted disease during the seventh year or earlier, the rate of increase was only 4.8 nuts per year. Compared to this, in palms which became diseased after initiation of flowering, the growth rate was 8.7 nuts. In the case of palms which contracted disease during the eighth to the tenth year, the linear regression line was not found to give a good fit. This was because the yield started declining by the tenth year, due to the initiation of disease during this period. Irrespective of the year of incidence of disease, palms receiving Mg treatment were found to show a higher rate of increase in yield, compared to that of the palms not receiving Mg treatment.

In the case of D × T palms, the year to year fluctuations in yield were more and no clear linear trend was seen for the yield in the initial years. However, in general terms it can be stated that in healthy palms the yield was increasing at the rate of 12.6 nuts, whereas in palms which contracted disease earlier, the rate of increase was less (2.5 nuts).

Since the yield of palms is affected once they contract the disease, an attempt was also made to describe the yield trend during the initial years by using a curvilinear regression model of the form $y = a + bx + cx^2$, where x is the age of the palm and y is the expected yield. In all cases, a better fit was observed, than in the linear model, as evidenced by the high $R^2$ values (Table 78.3). The increase in $R^2$ values was substantial in the case of palms which contracted disease in the eighth year or later. It is seen from the empirical relationships presented in Table 78.3 that though the rate of increase in yield was low in palms which contracted disease during the pre-bearing period, the rate of decline in yield was more rapid in palms which contracted disease in later years.

**d) Loss in Yield**

It was clearly seen that the palms which contracted disease during the later years, the cumulative yield was less, compared to that of healthy palms (Table

78.4). Magnitude of the loss was found to gradually come down, as the age at initiation of disease was increasing.

Though the D × T palms were giving higher yields, in relative terms, the loss in yield was comparable with that of West Coast Tall palms.

**Table 78.4:** Cumulative yield of nuts and loss in yield due to initiation of disease at different periods

| *Age (years) at initiation of disease* | *No. of palms* | *10th year* | | *12th year* | | *14th year* | |
|---|---|---|---|---|---|---|---|
| | | *Cum. yield* | *Loss (%)* | *Cum. yield* | *Loss (%)* | *Cum. yield* | *Loss (%)* |
| a) *WCT* | | | | | | | |
| 3, 4, 5 | 23 | 57.8 | 68.5 | 122.8 | 64.0 | 188.7 | 61.2 |
| 6, 7 | 76 | 90.5 | 50.6 | 160.3 | 52.9 | 227.2 | 53.4 |
| 8, 9, 10 | 92 | 120.2 | 34.4 | 186.5 | 45.3 | 242.8 | 50.2 |
| 11, 12, 13 | 171 | 180.1 | 1.7 | 315.5 | 7.4 | 422.2 | 13.4 |
| Healthy | 172 | 183.3 | | 340.7 | | 487.3 | |
| b) *D x T* | | | | | | | |
| 4, 5, 6 | 10 | 65.2 | 88.3 | 103.3 | 85.7 | | |
| 8 | 9 | 312.1 | 44.1 | 374.5 | 48.3 | | |
| 9 | 40 | 488.2 | 12.6 | 525.9 | 27.4 | | |
| 11 | 56 | 475.9 | 14.8 | 568.6 | 21.5 | | |
| Healthy | 190 | 558.5 | | 724.2 | | | |

**e) Relationship Between Disease Intensity and Yield**

A steady decline in yield was observed with increase in the intensity of disease, in all the years (Table 78.5). The linear regression model showed that the yield was declining at the rate of 10 to 13 nuts, in the different years, for every 10-point increase in disease index. In the years of high yield, the rate of decline was also found to be high. The diseased West Coast Tall palms were found to give, in general, about 45 per cent lesser yield compared to the healthy palms.

Similar results were obtained for D × T palms also. The average yield of palms ranged from 28 to 100 nuts during this period. The rate of decline in yield was also found to be higher, compared to West Coast Tall, and it ranged from six to 27 nuts in the different years. The annual loss in yield due to disease was around 60 per cent in the different years.

Jose Abraham *et al.* (1987) had also reported similar results. According to them, in cultivators' gardens, where the mean yield was around 25 nuts only, the rate of decline in yield was five nuts for every 10 point increase in index. Under well managed conditions, with an average yield of 53 nuts, this rate of decline was up to 13 nuts.

From the foregoing discussion it is clear that in palms which have contracted disease during the early years after planting, the flowering is not only delayed, but the yield of nuts is also affected. In addition to loss in yield, Cecil *et al.* (1984) have also reported that the disease caused about 12 per cent

reduction in copra weight per nut. Disease was also reported to reduce the percentage of plaitable leaves, the weights of whole nut, husked nut and husk, and oil content (Anonymous, 1985).

**Table 78.5:** Frequency distribution of palms on the basis of disease intensity and regression of yield on disease index

| *Disease index class* | *1982* | | *1983* | | *1984* | |
|---|---|---|---|---|---|---|
| | *No. of palms* | *Mean yield* | *No. of palms* | *Mean yield* | *No. of palms* | *Mean yield* |
| a) *West Coast Tall* | | | | | | |
| 0 | 231 | 71.8 | 181 | 81.8 | 183 | 64.0 |
| 11–20 | 20 | 56.7 | 35 | 75.4 | 40 | 59.4 |
| 21–30 | 85 | 52.7 | 94 | 61.8 | 102 | 48.7 |
| 31–40 | 95 | 40.9 | 107 | 49.7 | 84 | 30.1 |
| 41–50 | 77 | 28.1 | 78 | 28.3 | 83 | 23.5 |
| > 50 | 26 | 11.8 | 39 | 9.6 | 42 | 14.5 |
| Tot. Dis. | 303 | 39.5 | 353 | 46.3 | 351 | 35.4 |
| | | (45.0) | | (43.4) | | (44.7) |
| Pooled | 534 | 53.6 | 534 | 58.3 | 534 | 45.1 |
| Regression equation | $y = 75.4 - 1.07x$ $R^2 = 0.97$ | | $y = 91.1 - 1.34x$ $R^2 = 0.93$ | | $y = 69.0 - 0.97x$ $R^2 = 0.94$ | |
| b) *D x T* | | | | | | |
| 0 | 247 | 72.9 | 191 | 128.9 | 191 | 36.8 |
| 11–20 | 19 | 43.3 | 40 | 56.7 | 22 | 11.4 |
| 21–30 | 29 | 27.9 | 59 | 58.6 | 68 | 17.5 |
| 31–40 | 15 | 21.3 | 20 | 38.2 | 24 | 7.6 |
| 41–50 | 0 | – | 0 | – | 5 | 11.4 |
| Total Dis. | 63 | 31.0 | 119 | 54.5 | 119 | 14.1 |
| | | (57.5) | | (57.7) | | (61.7) |
| Pooled | 310 | 64.4 | 310 | 100.3 | 310 | 28.1 |
| | $y = 72.0 - 1.66x$ $R^2 = 0.99$ | | $y = 121.5 - 2.74x$ $R^2 = 0.92$ | | $y = 31.2 - 0.60x$ $R^2 = 0.71$ | |

Note: Figures in the parantheses denote the loss in yield (%) due to disease.
x : mean disease index. y : mean yield of nuts.

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## REFERENCES

Anonymous. 1985. Coconut root (wilt) disease intensity, production loss and future strategy — A Survey Report, CPCRI, Kasaragod. pp. 45

Cecil, S.R., Pillai, N.G., Kamalakshy Amma, P.G., Mathew, A.S. and Nambiar, P.T.N. 1984. Effect of major nutrients on the incidence of root (wilt) disease in coconut. In: *Proc. Placrosym V (1982)*, Indian Society for Plantation Crops, CPCRI, Kasaragod, India. pp. 474–481.

George, M.V. and Radha, K. 1973. Computation of disease index of root (wilt) disease of coconut. *Indian J. agric. Sci.* **43**: 366–370.

Jose Abraham, Rawther, T.S.S., Jacob, P.M. and Cecil, S.R. 1987. Trend in yield of root (wilt) affected coconut palms (*Cocos nucifera* Linn.). *J. Plantn. Crops* **15**(1): 32–41.

Menon, K.P.V. and Pandalai, K.M. 1958. *The Coconut Palm—A Monograph*. Indian Central Coconut Committee, Ernakulam, pp. 384.

Ramadasan, A., Shanta, P. and Lal, S.B. 1971. Resistance or susceptibility, age of bearing and yield in young coconut palms in relation to development of root (wilt) disease. *Indian J. agric. Sci.* **41**: 1107–1109.