Symptoms associated with water deficit in oil palm

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Introduction

Oil palm has long since been known as a crop with considerable water demands, and it generally develops in regions with precipitation levels above 2,000 mm and lacking prolonged droughts. A water supply of at least 150 mm/month is necessary for an optimum yield and performance (Hemptinne & Ferwerda, 1961). This is a condition which is seldom met, and it is frequent to find plantations where the water supply becomes critical several months in a particular year. In Costa Rica plantations, an accumulated water deficit is normally found only during the dry season, in the Pacific Central region (Quepos-Parrita), with an average deficit of 269.8 mm (standard deviation: 105.5 mm), according to data recorded over a 9 year period (D.L. Richardson, personal communication). The purpose of this description is to guide the reader to the recognition of several symptoms associated with water deficit in plants of different ages.

Plants ten years old and up

In some areas of Quepos, it is common that plants suffer water deficit each year, and it is frequent to observe a premature folding over of the intermediate and inferior leaves, while they are still green (Fig. 1F). Very similar symptoms were described by Willard, Daniel & Ochs (1974) for even more severe drought conditions in West Africa. Some plants presented bent leaves as young as number nine, even though it was more frequent to find older leaves affected, up to position number 16. Premature leaf folding made its appearance associated with the accumulation of unexpanded new leaves (spears) in the plant (Fig. 1E). The most affected areas have soils and/or topography that favor water deficit, a condition that may lead to an earlier manifestation of the symptoms in these areas.

Once the older leaves were folded, they maintained their stomata closed during most part of the day, except for a few hours early in the morning. The reduced photosynthetic activity of these leaves, and their inability to translocate nutrients efficiently to the rest of the plant (due to the mechanical damage to the petiole), will possibly render them useless to the plant.

The magnitude of this reduction in leaf area was in direct relation with the intensity of the stress; some evidence (Villalobos, et al. 1990) indicates that the folding of those leaves probably responds in part, to a need to reduce the transpiration surface, and to help the young leaves maintain their water balance.

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Two years old and younger plants

The symptoms here described were observed in an area in Quepos, where because of differences in the soil water holding capacity, the sub-irrigation method in use presented variable efficiency levels. This condition, in conjunction with a severe dry season (Table 1), made it possible to observe plants with varying degrees of water deficit (Fig. 1B).

<table>
<thead>
<tr>
<th>Site</th>
<th>Dec-88</th>
<th>Jan-89</th>
<th>Feb-89</th>
<th>Mar-89</th>
<th>Apr-89</th>
<th>Deficit, mm</th>
<th>Water holding capacity, mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palo Seco, Quepos</td>
<td>55.0</td>
<td>2.0</td>
<td>0.0</td>
<td>0.1</td>
<td>47.3</td>
<td>436.5</td>
<td>225</td>
</tr>
<tr>
<td>Capital, Quepos</td>
<td>142.8</td>
<td>15.0</td>
<td>0.0</td>
<td>4.1</td>
<td>65.1</td>
<td>427.9</td>
<td>150</td>
</tr>
<tr>
<td>Coto 49, Coto</td>
<td>199.0</td>
<td>28.0</td>
<td>0.0</td>
<td>133.0</td>
<td>93.0</td>
<td>298.2</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 1. Rainfall (mm) and estimated water deficit (mm) in three areas of Costa Rica during the 1989 dry season

In very young plants (1-2 years old), the most evident symptom of water deficit was the accumulation of spear leaves (Fig. 1A). With the progression of the dry season, these plants presented an inward curling of the leaflets (rolling), and later necrosis of leaves, beginning on the tips of the leaflets of lower leaves (Fig. 1A & Fig.1B). In extreme cases, the necrosis of tissues extended to younger leaves with no previous chlorosis of the laminae.

Under extreme water deficit conditions, root necrosis of every order could be observed, and occasionally, the death of a few plants. However, some badly affected plants reinitiated growth at the beginning of the rainy season. Young plants responded quite different from adult palms. The latter, because their large stem and extensive root system are able to buffer some of the negative effects of the water deficit.

Four year old plants

Coto, a region in Southern Costa Rica, does not normally present water deficit. Nevertheless, the 1989 dry season (Table 1) was rather severe in this region, and symptoms of water shortage were observed in some areas. Four year old plants grown in a soil with a reduced capacity to retain moisture, with a superior horizon 7-10 cm deep, followed by a layer of accumulated gravel of variable depths, began to develop severe deficit symptoms. Partly due to the aforementioned characteristics of the soil, the observed symptoms were the result of a combination of a deficient water supply and nutritional deficiencies, mainly nitrogen and magnesium (Fig. 1C). The vegetative growth of these plants was markedly reduced for their age; the variables in Table 2 show a reduced accumulation of dry vegetative matter and a poor vegetative development, when compared to plants of the same age and material growing under more normal conditions.
In March, the plant presented several spears, besides yellowing and/or bronzing starting at the tips of intermediate and inferior leaves. Initially, the leaflets tissue necrosed between the veins, and a overall desiccation of the whole leaf followed (Fig. 1C & Fig. 1E). In some cases, the yellowing was more accentuated on one side of the leaf. The bunches already formed were small, and fruit ripening was delayed. Bunch failure was common.

In spite of their reduced length and weight (Table 2), some intermediate and inferior leaves were broken at the rachis, approximately at one third from the leaf base (Fig. 1D). This phenomenon may be considered analogous to the premature folding of the green lower leaves in adult palms under stress. Nevertheless, it was obvious, in this case, that this was not a mechanism to reduce moisture deficit effects within the plant, but a consequence of very severe stress conditions.

<table>
<thead>
<tr>
<th>Water deficit</th>
<th>Trunk height dry weight</th>
<th>Trunk dry weight</th>
<th>Petiole length</th>
<th>Rachis length</th>
<th>Frond number</th>
<th>Leaf dry weight</th>
<th>VDM Leaf (Kg²)</th>
<th>Leaf area (m²)</th>
<th>Total leaves</th>
<th>Spears</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficit</td>
<td>0.155 3.05 0.81 2.87 30 1.4 45.0 5.7</td>
<td>171.9 4</td>
<td>0.055 0.95 0.98 3.04 28 1.0 28.9 4.9</td>
<td>137.8 3</td>
<td>0.105 2.20 1.08 3.12 36 1.1 41.7 5.5</td>
<td>199.8 4</td>
<td>0.140 2.30 0.85 3.38 27 1.3 37.4 7.5</td>
<td>201.7 3</td>
<td>0.085 1.20 0.89 3.49 22 1.2 27.6 4.6</td>
<td>102.3 4</td>
</tr>
<tr>
<td>Average</td>
<td>0.12 1.60 0.92 3.13 28 1.3 36.0 5.9</td>
<td>164.6 4</td>
<td>0.80 16.00 1.30 4.69 38 2.0 93.1 6.3</td>
<td>238.0 1</td>
<td>0.72 20.10 1.45 4.76 40 2.1 105.0 7.2</td>
<td>288.6 1</td>
<td>0.68 16.90 1.21 4.20 43 1.7 88.4 5.2</td>
<td>224.4 1</td>
<td>0.50 19.80 1.37 4.68 43 2.2 113.1 6.4</td>
<td>275.0 1</td>
</tr>
<tr>
<td>Normal</td>
<td>0.63 18.20 1.33 4.58 41 2.0 99.9 6.3</td>
<td>256.5 1</td>
<td>0.80 16.00 1.30 4.69 38 2.0 93.1 6.3</td>
<td>238.0 1</td>
<td>0.72 20.10 1.45 4.76 40 2.1 105.0 7.2</td>
<td>288.6 1</td>
<td>0.68 16.90 1.21 4.20 43 1.7 88.4 5.2</td>
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</tr>
</tbody>
</table>

Variables determined according to Corley & Breure, 1981.

An excellent indicator of water availability in the soil was the appearance of the cover crop (Pueraria phaseoloides), in which the symptoms of water stress first showed up; the foliage dried up, leaving only a few small yellowish leaves, giving the appearance of being intoxicated by a contact herbicide (Fig. 1A-1F).
Fig 1A. Symptoms associated with water deficit in 10 month old plants in the field.

Fig 1B. Symptoms associated with water deficit in 10 month old plants in the field.

Fig 1C. Symptoms associated with water deficit in four month old plants in the field.

Fig 1D. Symptoms associated with water deficit in four year old plants in the field.
Fig 1E. Symptoms associated with water deficit in four year old plants in the field.

Fig 1F. Symptoms associated with water deficit in 22 year old plants in the field.

References


