

Diagnostic Tests for Redpalm Weevil, *Rhynchophorus ferrugineus* Infested Datepalm Trees

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ABSTRACT. Redpalm Weevil, *Rhynchophorus ferrugineus* is an insect which has caused infestation of datepalm trees in the eastern region of the Kingdom. The insects bore into the tree trunk and feed on the soft tissues resulting in die-back of leaves. Symptoms become visible when brownish fluid begin to ooze out of the tree trunk and by that time it is too late to save the trees.

This study was undertaken to evaluate some of the physiological parameters as indices of infested trees at an early stage of attack by the insect. Results indicate that in infested trees the rate of transpiration was higher while the diffusive resistance was lower as compared to healthy trees. Similarly, the water potential in infested trees was lower than the healthy trees. Rate of transpiration or diffusive resistance or water potential either alone or in combination could be used as indices of infested trees.

Redpalm Weevil *Rhynchophorus ferrugineus* (Plates I, II, III) is one of the most harmful insect of palm tress (Lever 1969, Wygner 1962, Rahalkar *et al.* 1983). It was introduced into the Kingdom through imported palm trees. It has already caused tremendous damage to the datepalms in the eastern region. In young trees, the larvae bore into the tree trunk near the base of the heartleaf and feed on the soft tissues inside resulting in die-back of leaves and eventually the tree dies, while in older trees, the larvae attack the trunk anywhere at any height (Frohlich and Rodewald 1970, Sharif and Wajih 1983). Visible symptoms become noticeable when most of the damage has been done, and the infested trees cannot be easily saved by insecticide treatment.

Usually such trees are cut and burnt to prevent further proliferation of the disease. One of the major problems right now is, how to identify the infested trees

so that preventive measures could be taken at an early stage by injecting insecticide through the tunnels created by the larvae or by cutting and burning the trees. The infested trees can not be distinguished from the healthy ones at an early stage of attack by the larvae. The trees look normal in appearance even when the insect is feeding on the tissue inside the tree trunk and becomes noticeable only when brownish fluid begins to ooze out of the trunk and the leaves begin to fall. By that time it is too late to do anything about it. Although visible symptoms of the infested trees are not noticeable, the physiology and metabolic processes are altered adversely at the on-set of attack which eventually leads to the death of trees.

This study was undertaken to evaluate the physiology of healthy and infested trees and screen the important parameters as indices of infested condition at an early stage of attack by the beetle.

Materials and Methods

This study was conducted on datepalms in private farms in Qatif in the eastern region. Healthy and infested trees were selected to monitor their physiological and metabolic status using different techniques. These included measurement of water potential, rate of transpiration, stomatal conductance, temperature and chlorophyll fluorescence test. Young and old infested trees were selected by an expert entomologist. The study also included infested trees treated with insecticide, Phostoxin. Relative humidity, stomatal conductance, temperature and rate of transpiration were measured using model LI-1600 porometer. Chlorophyll fluorescence was measured using portable chlorophyll meter (Kanemasu *et al.* 1969). Water potential of leaf was determined using the pressure bomb technique (Scholander *et al.* 1964).

Results and Discussion

Data in Tables 1 to 6 show relative humidity within the cuvette holding the leaf, diffusive resistance of the leaf, rate of transpiration, temperature of the leaf and the chlorophyll fluorescence. The data in Table 1 indicate that there was no significant difference in the relative humidity of the leaf or the temperature of the leaf. However, there were slight differences in diffusive resistance and significant difference in the rate of transpiration between healthy and infested plants. Diffusive resistance of the healthy plants was much higher than the infested plants and this was also reflected in higher rate of transpiration in the infested plants. Infested plants were thus losing more water than the healthy plants due to lower stomatal resistance to the flow of water from the intercellular spaces to the outside atmosphere. This clearly indicates that infested plants had lost the vigor to conserve water due to altered metabolism.

Similar trends were noticed in plants in Tables 2 and 3, again indicating that diffusive resistance and rate of transpiration were significantly different in healthy vs infested plants. Table 4 shows data on healthy, infested and infested but insecticide treated- plants. Diffusive resistance of infested plants was lower than that of healthy and treated plants. Rate of transpiration was higher among infested plants but lower in treated plants.

This clearly indicates that among infested plants, both diffusive resistance and rate of transpiration are adversely affected and the slight recovery noticed in these following insecticide treatment further support the conclusion stated above.

Table 1. Physiology of infested and healthy younger plants at Qatif experimental site

	R. Humidity (%)	Diffusive Resistance (cm/S)	Transpiration ($\mu\text{g}/\text{cm}^2 / \text{S}$)	Leaf Temperature ($^{\circ}\text{C}$)
Healthy Plants	30.19	0.020	160.0	35.20
	30.59	0.050	127.0	35.20
	30.59	0.060	132.2	35.30
	29.80	0.040	140.0	35.30
	29.80	0.060	136.9	35.10
Infested Plants	29.02	0.000	205.0	35.30
	28.63	0.000	201.5	35.40
	27.84	0.000	198.5	36.00
	27.06	0.000	193.0	36.40

Table 2. Physiology of infested and healthy older plants at a private farm near Qatif

	R. Humidity (%)	Diffusive Resistance (cm/S)	Transpiration ($\mu\text{g}/\text{cm}^2 / \text{S}$)	Leaf Temperature ($^{\circ}\text{C}$)
Healthy Plants	36.47	0.180	54.19	32.10
	36.86	0.050	100.3	31.90
	36.86	0.030	112.4	31.50
	36.86	0.020	172.4	31.70
Infested Plants	28.63	0.000	177.1	30.50
	32.55	0.000	185.0	30.90
	33.33	0.010	127.9	31.10
	36.47	0.010	142.8	30.90

Table 3. Physiology of infested and healthy younger plants at a private farm near Anak

	R. Humidity (%)	Diffusive Resistance (cm/S)	Transpiration (μ g/cm² /S)	Leaf Temperature (°C)
Healthy Plants	30.43	0.070	118.3	30.30
	35.68	0.140	62.83	30.50
	35.29	0.190	59.46	30.50
	36.47	0.220	53.07	30.70
Infested Plants	33.33	0.010	118.2	27.90
	34.51	0.000	122.8	28.50
	35.68	0.000	135.3	28.70
	37.25	0.000	168.1	29.30
	36.46	0.010	144.7	29.70
	37.25	0.020	115.8	29.90
	36.47	0.020	106.4	29.70

Table 4. Physiology of infested, healthy and insecticide-treated younger plants near Qatif

	R. Humidity (%)	Diffusive Resistance (cm/S)	Transpiration (μ g/cm² /S)	Leaf Temperature (°C)
Healthy Plants	36.47	0.330	39.36	29.50
	38.04	0.110	76.99	31.00
	37.25	0.430	35.63	31.60
	37.25	0.130	75.03	31.60
	37.64	0.930	17.83	30.50
	36.47	0.610	26.01	30.50
Infested Plants not treated with insecticide	33.33	0.000	135.50	28.30
	34.11	0.000	144.10	28.70
	33.73	0.000	135.00	29.30
Infested Plants treated with insecticide	36.47	0.060	69.89	26.10
	37.25	0.030	85.82	25.90
	36.47	0.070	67.53	25.90



Plate I. Freshly emerged Redpalm Weevils (inside the datepalm trunk)

In Table 5 are the data on water potential of healthy and infested plants. Infested plants showed significantly lower water potential (more negative) than healthy plants which is in conformity with the findings on diffusive resistance and rate of transpiration.

The healthy plants were able to maintain high water potential to cope with any stressed conditions, may it be water stress or heat stress. On the other hand, the infested plants with lower water potential had lost the vigor to adjust to any stress conditions and therefore these plants were more vulnerable to adverse atmospheric conditions.

Table 6 shows the chlorophyll fluorescence of healthy, infested and insecticide-treated trees. There is no difference between the chlorophyll content of healthy and infested trees which indicates that chlorophyll contents are not affected immediately and this is why that even the infested trees appear normal throughout much of the duration of the infestation inside the tree trunk.

It is possible that the infested trees are not synthesizing new chlorophyll but simply maintaining the previously-accumulated chlorophyll. How active the chlorophyll is in maintaining the rate of photosynthesis is not known. It will be

interesting to monitor the rate of photosynthesis of the infested vs healthy plants. The hypothesis that the rate of photosynthesis of infested trees is lower than healthy trees will indicate that the chlorophyll in the infested trees are not fully functional. Their structural configuration might have been altered to the extent to affect the photosynthesis but not the total concentration.

The slightly high concentration of chlorophyll in the insecticide treated trees may be due to the stimulating effect of insecticide on synthesis of chlorophyll. It has been shown that some herbicide such as 2, 4-D acts like hormone when applied to plants in small concentration. It is possible that some insecticide may have hormone-like action on chlorophyll synthesis in datepalms. However, it can not be

Table 5. Water Potential ($-\bar{w}$) of Healthy and Infested datepalm trees

Healthy Plants	Infested Plants
- 11.2	- 30.0
- 20.2	- 30.2
- 5.2	- 31.2
- 1.6	- 10.8
- 10.8	- 18.2
- 3.6	- 16.4
- 4.2	- 12.2
- 3.8	- 22.6
- 5.4	- 15.4

Table 6. Chlorophyll Fluorescence of Healthy and Infested datepalm trees

Healthy Trees	Infested Trees	Infested but Treated
67.5	67.75	79.25
72.0	60.00	72.75
73.66	66.00	78.00
72.66	69.75	76.00
74.75	66.00	74.00
70.33	72.5	
74.5	64.3	
75.0	74.0	
70.0	69.5	
73.5	65.5	
76.5	69.5	
73.0	76.00	
78.0		
76.0		
74.0		
73.42	68.40	76.00



Plate II. Redpalm Weevil (Adult)



Plate III. Redpalm Weevil (Grub)

substantiated from this study that the insecticide used on these trees has any hormone-like action.

The most interesting aspects of this study are:

1. The physiology of infested trees is different and adversely affected compared to the healthy trees.
2. The parameters such as diffusive resistance and rate of transpiration could be used as an index of the infested trees. For example, the differences noticed in the same tree on infested vs non-infested sides confirms this conclusion. Following extensive study, this method may prove as a valuable tool for detecting the infestation at an early stage.

Conclusion

As indicated earlier, this was a preliminary reconnaissance study aimed at testing the feasibility of the techniques for screening the infested trees. Indications based on this study are that a well-planned study should be prepared and implemented on a large scale to include all possible fallacies such as water-stressed or heat-stressed conditions. Water-stressed or heat-stressed trees might exhibit changes in physiology similar to the infested trees. It is therefore important to study all known types of stress conditions to isolate the cause/effects of different environmental factors. Another important aspect of the study should be to evaluate the rate of photosynthesis which could not be measured at this time. The changes observed in diffusive resistance and rate of transpiration should be reflected in rate of photosynthesis. Diffusive resistance, rate of transpiration and photosynthesis are interdependent processes. Any stress such as condition caused by disease, water or heat affecting one process may influence other interrelated and interdependent processes. Following extensive study, the parameters measured will be analyzed statistically to draw conclusions and make recommendation for practical use of the most appropriate and economically feasible method for detection of the infested trees at an early stage of attack.

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الفحوص التشخيصية لسوسة النخيل الحمراء (الآسيوية) التي تصيب نخيل التمور

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تعتبر سوسة النخيل الحمراء الآسيوية *Rhynchophorus ferrugineus* من أخطر الحشرات التي تهاجم النخيل بصورة عامة ومن ضمنها نخيل التمور. وقد دخلت هذه السوسة المملكة العربية السعودية مع شتلات نخيل الزينة المستوردة في أواخر عام ١٤٠٦ هـ وقد تسببت حتى الآن في إحداث أضرار كبيرة لبساتين نخيل التمور في المنطقة الشرقية للمملكة.

تحفر يرقات السوسة بداخل جذع النخلة الصغيرة عند قواعد سعف القلب للجھارة فتتغذى على الانسجة الطرية محدثة الموت التدريجي أو البطيء وتهدل السعف ومن ثم موت تلك النخلة، بينما في النخل الكبير فان اليرقات تصيب الجذع في أي مكان وعند أي ارتفاع.

تظهر الأعراض بعد تقدم الإصابة عادة مثل Dieback وسيلان عصارة النخلة البنية الفاتحة لخارج الجذع بصورة مستمرة ثم تسود نتيجة الأكسدة وتكون لتلك العصارة رائحة نفاذة وذلك بعد أن يكون أغلب الضرر قد حدث للنخلة. وهذا النخيل يقطع عادة ويحرق ويدفن تحاشياً لانتشار الإصابة.

رغم أن أعراض الإصابة المرئية للنخل المصاب لا تكون ملاحظة عادة، إلا أن وظائف الأعضاء وعمليات الأيض Metabolism تتغير بصورة عكسية عند أول إصابة مما يؤدي إلى موت الأشجار المصابة.

نُفذت هذه الدراسة لتقدير عدد من القياسات أو المؤشرات الفسيولوجية لنخيل سليم وآخر مصاب، وإمكانية الاستفادة من النتائج باستخدامها كمؤشر أو دليل على الحالة المرضية عند أي طور من الإصابة.

وجد من نتائج تلك القياسات أنه لا توجد فروق معنوية في الرطوبة النسبية أو الحرارة لقواعد الأوراق (اباط الاوراق Cuvette)، بينما هناك فروق معنوية في معدل النتح Transpiration مقدراً بالميكروجرام/ سم² / ثانية ومقاومة الانتشار Diffusive resistance مقدراً بالسنتيمتر/ الثانية حيث كانت مقاومة الانتشار للنخيل السليم أعلى كثيراً من النخيل المصاب المعامل بالمبيدات، والأخير أعلى من النخيل المصاب غير المعامل. أما معدل النتح فقد كان في النخيل المصاب أعلى النتح كثيراً منه عن المصاب المعالج بالمبيدات، والأخير المعالج أكثر من النخيل السليم. وذلك يعني أن النخل المصاب يفقد ماء كثيراً مقارنةً بالنخل السليم. يعزى ذلك إلى المقاومة الأقل للفتحات الصغيرة (Stomata) في النخل المصاب لسريان الماء من الفراغ الداخلي له إلى الجو الخارجي مما يعني فقدان النبات المصاب القدرة على المحافظة على الماء نتيجة تغير عمليات الأيض.

كما وجد أن النباتات المصابة أظهرت جهداً مائياً أقل (أكثر سلبية) عن النباتات السليمة وذلك نتيجة لزيادة النتح وقلة مقاومة الانتشار المائي للنباتات المصابة عن السليمة حيث أن النباتات السليمة قادرة على الحصول على ضغط مائي أعلى لتعويض حالات الإجهاد مثل الإجهاد المائي والإجهاد الحراري، بينما النباتات المصابة ذات الجهد المائي الأقل قد فقدت القوة أو النشاط لتعديل أي حالة إجهاد، لذلك فإن النباتات المصابة كانت أكثر تعرضاً لأي إجهاد نتيجة الأحوال الجوية.

مقارنة الاستشعاع الكلوروفيلي للأشجار السليمة، والمصابة، والمصابة المعاملة بالمبيدات أظهرت عدم وجود فروق جوهرية في المحتوى من الكلوروفيل بين النخيل السليم والنخيل المصاب مما يدل على أن المحتوى من الكلوروفيل لم يتأثر بسرعة مما يفسر ظهور النخيل المصاب وكأنه سليم في مظهره رغم تقدم الإصابة بداخل النخلة.

وبهذا نستخلص أن وظائف الاعضاء للأشجار المصابة تختلف وتتأثر كثيراً مقارنة بمثيلاتها من الأشجار السليمة. وأن بعض القياسات مثل مقاومة الانتشار، ومعدل النتج يمكن استخدامها كمؤشرات لإصابة أشجار النخيل بسوسة النخيل الحمراء.

تمت هذه الدراسة على عدد قليل من الحقول ولفترة قصيرة، ويفضل إعادتها على نطاق أوسع ولفترة أكبر وحسب برنامج دقيق على أن تحتوي على قياسات أخرى مثل التمثيل الضوئي وحالات الإجهاد المائي والاجهاد الحراري. من المتوقع أن الأشجار المجهد مائياً، والمجهد حرارياً قد تظهر تغيرات فسيولوجية مشابهة للأشجار المصابة. لذلك من الأهمية بمكان دراسة كل أنواع الإجهاد المعروفة لفرز الأسباب والمؤثرات البيئية المختلفة وذلك لاستنتاج أكثر تلك القياسات اقتصادياً وعملياً لتحديد الأشجار المصابة وعند أي مستوى من الإصابة.