Early Detection of pest attack in trees using Embedded System

Yogini Prabhu , Dr. J.S.Parab , Dr. R.S.Gad , Dr. G.M.Naik
Department of Electronics, Goa University, Taleigao Plateau, Goa

Abstract: Borer pests are responsible for tremendous destruction of forest resources and reducing the green coverage in the globe. They also cause losses in produces of commercial crops, thus torment to the farmers. In this paper, we have presented the results of spectro-photometric method of chlorophyll absorbance measurement of Cashew leaves, which shows that there is considerable change in the chlorophyll content, which means tree is under attack by pest. Also, in this paper, we have proposed the design of an portable embedded system which can perform the prompt and accurate early detection of the pest infestation by analysing the change in Chlorophyll content. The whole system will be designed around the ARM controller.

Keywords: Stem borer, Agro-electronics, Embedded, chlorophyll estimation, pest attack

I. Introduction

Borers have been found generally to infect the trees leading to their death in period of six months. The damage by the bark beetles to forests is explained from the following cases:

1) In case of forests, the insect damage causes the carbon sink of forests to turn into carbon source [1]. There has been a 4-fold increase in monoterpene emissions and up to a 40% increase in SOA (secondary organic aerosol) concentrations in some years (as observed lodgepole pine response), as result of Beetle infestations.

2) The enormous area of dead forests attacked by such pests is susceptible to forest fires, as the damaged forests trees being dry are highly inflammable [2].

The cases of the beetles' attacks all over the world are known as follows:

1) The Japanese cypress bark beetle, *Phloeosinus rudis*, *P. bicolor* and *P. thujae* killed numerous shrubs and trees of Cupressaceae in The Netherlands, in the summer of 2004 [3].

2) Extensive beetle outbreaks by mountain pine beetle (MPB), on the lodgepole pine and ponderosa pine have destroyed over lakhs of km^2 of forest throughout British Columbia and the western United States[4].

3) A tree-killing bark beetle, *Dendroctonus frontalis* is a destructive forest pest in the southeastern United States[5].

4) In Norway, *Ips typographus* is the major tree-killing bark beetle attacking spruce *Picea abies*[6].

Locally in case of the cashew (Anacardium occidentale L), the severe borer pest attacks by the Cashew Stem and Root Borer (CSRB) *Plocaederus ferrugineus* pest leads to significant reduction in cashew nut yield [7]. Since cashew is an important commercial plantation crop (with an enormous potential for foreign currencies), huge financial losses are faced by the farmers.

Thus, our main objective is to develop an embedded system for early detection of 'Stem and Root Borer' pest in cashew trees so that remedial measures can be adopted to restore the Tree. Here we are trying to detect the early attack by analyzing the chlorophyll Absorbance spectra**.**

II. Literature review

Infestations by insect pests is one of the major causes of yield reduction in most of the cashew growing regions of our country ; the two major insect pests being Cashew Stem and Root Borer (CSRB) scientifically known as *Plocaederus ferrugineus*, and Tea Mosquito Bug (TMB) scientifically known as *Helopeltis antonni*.

In Kerala and Tamilnadu, the extent of attack of Cashew Stem and Root Borer (CSRB) were found be significant, of 7-20 % and 30-35 % loss respectively (Misra and Basu Choudhary, 1985). The infestation was recorded up to as high as 40 % in Guntur and Prakasam districts of Andhra Pradesh (Arjuna Rao, 1978; Ayyanna and Rama Devi, 1986).

Moreover, the infested trees do not recover from the damage if the damage of the bark circumference is 50% or more, or with the leaf canopies yellowed [7]. And, the trees are becoming more vulnerable for pest insects such as *phloeosinus* species, as the summer drought and heat waves are predicted to be increased upon the climate change.

Thus, it is concluded that, the timely detection of the presence of CSRB infestation is of prime importance to the benefit of the farmers in the State**.**

The literature review focuses on the fact that upon attack by the pest, there would be changes in the physiology of the plant.

The two major changes are:

3.1 Reduction in chlorophyll content.

Leaf colors of a plant can be used to identify stress level due to its adaptation to environmental change (here in this case is infestation by pest) [8].

The proportion of chlorophyll a/b is considered as sensitive bio-marker of pollution & environmental stress. The absorbance properties facilitate the qualitative & quantitative analysis of them[9].

3.2 Measurable change in conductivity of the stem.

The two causes that would induce change in the conductivity of a healthy tree upon infestation, are as follows:

3.2.1 Destruction of xylem and phloem channels

Cashew Stem and Root Borer in its larval stage (grub) feeds on the bark portions of the stem and roots, by making irregular tunnels which enlarge as the grubs grow in size[7]. Thus, the water and food channels (i.e. xylem and phloem) get destroyed or clogged. This will result into a measurable change in conductivity over the desired concentration range.

3.2.2 Production of chemical (defensive) compounds in tree

In order to function and survive, plants produce a wide array of chemical compounds not found in other organisms. Because they cannot move, plants must also defend themselves chemically from herbivores, pathogens and competition from other plants. They do this by producing toxins and foul-tasting or smelling chemicals. Because the biology of plants differs from animals, their symptoms and responses are quite different [10].

Thus the study of defensive mechanism of plants plays the key factor in the designing the system for detection of pest damage by analyzing chlorophyll content.

III. Proposed Design

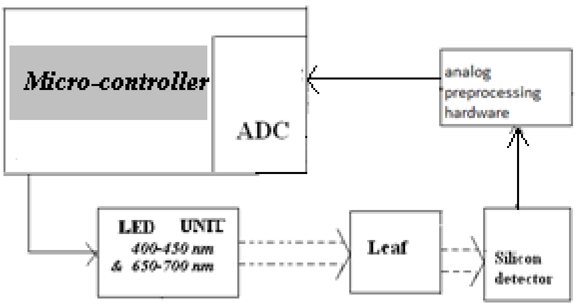

Fig 1: Block diagram of construction of the system

The Micro-controller unit is the heart of the entire system which controls the operation entire system. Here we will be selecting the 2 LEDs of of wavelength between 650-700 nm, 400-450 nm which corresponds to Chlorophyll Absorbance. We have selected the silicon detector (to detect the absorbance phenomenon) and a signal conditioning unit (to convert the output of the detector to suitable level for ARM 7). The input to the LED unit will be voltage signal from the ARM 7 unit. The output of the signal conditioning unit will be converted to digital form by ARM 7.

The design of Chlorophyll measurement channel will be based on the Beer lambart law.

Beer lambart law states that the transmittance (T) of material sample is related to its optical depth τ and to its absorbance A as

$$T = \Phi_e^t / \Phi_e^i = e^{\tau} = 10^{-A}$$

where Φ_e^t is the radiant flux transmitted by that material sample and Φ_e^i is the radiant flux received by that material sample

IV. Experimental setup

Spectroscopy was performed on the samples of leaves of healthy as well as infested trees, in the visible range, using Ocean Optics SPECTRAsuite software. The light source used was the Quartz Tungsten Halogen (*QTH*) Lamp and Spectrometer was USB 2000+.

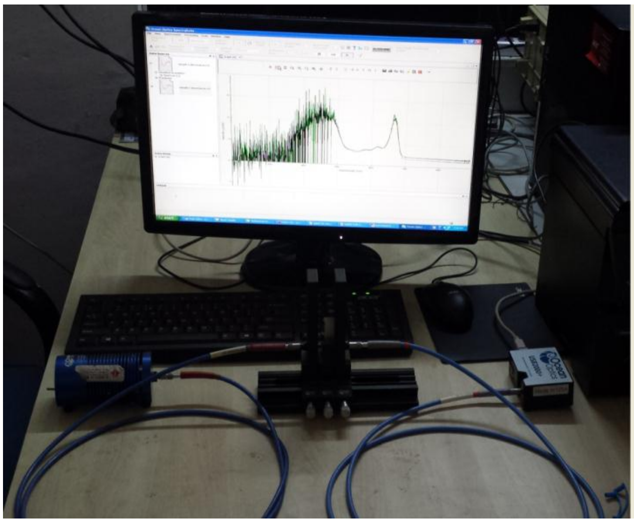

Fig 2: Picture of experimental setup; with Quartz Tungsten Halogen (*QTH*) Lamp (light source), cuvette holder and Spectrometer USB 2000+ (Left to right).

Material and Methods

Collection of plant samples: In this study, we focused on two cases of cashew trees from a commercially grown plantation; first category being healthy; second being infested by the CSRB. 2 samples of leaves of each selected trees were collected.

Care was taken during sampling of leaves to avoid mechanical injuries. Fresh leaf samples were washed thoroughly first in tap water followed by distilled water in the laboratory, kept to dry in room temperature (18 ^{o}C) and analyzed for the determination of absorbance of the leaf extract in DMSO.

Analytical procedure: To prepare the extraction samples, we work on a leaf mass basis, by weighing the material. Use scalpel to cut frozen or fresh leaves into 1 cm^2 sections. Use care when attaching blade and cutting sections as scalpel is razor sharp.

Accurately weighted 0.5g of fresh plant leaf sample and 3.5 gms of DMSO (Dimethyl-Sulphoxide) solvent was taken, and crushed in a crucible. The crushing causes the mixture to warm up, thus the glass cuvettes with the extractant is stored in cold storage for few minutes until the cuvette comes to room temperature.

V. Results

The absorbance characteristics of chlorophyll of healthy and infested cashew tree obtained over the visible light range (Fig. 3 and Fig. 4) were noted for the three wavelengths (in nm) 666.75, 620.02 and 586.05.

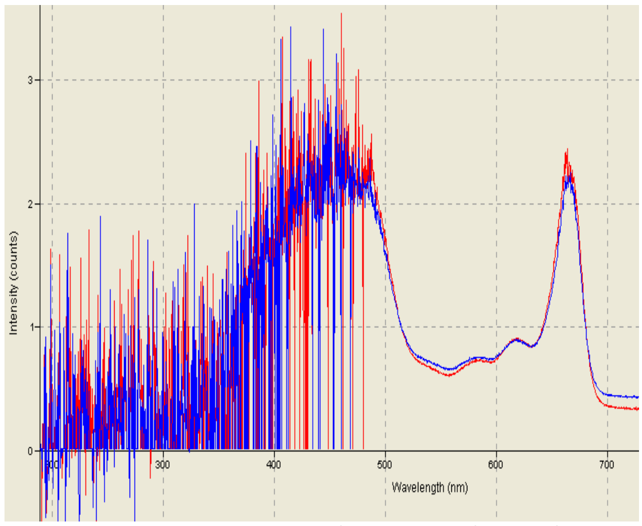

Fig 3: Spectra in visible light region of two samples of leaves of healthy cashew trees.

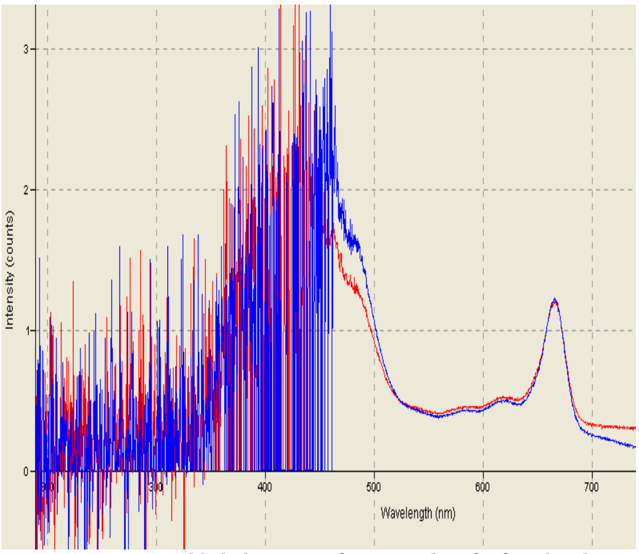

Fig 4: Spectra in visible light region of two samples of infested cashew trees.

As shown in the Table 1, there is drastic decrease in the absorbance (in OD) of light i.e. 1.0097, 0.503 and 0.4315 (in case of Infested cashew tree) compared to 2.414, 0.8925 and 0.729 (in case of healthy cashew tree) for the three wavelengths (in nm) 666.75, 620.02 and 586.05 respectively.

Table 1: Spectro-photometric determination of Absorbance (in OD) of leaf extract of cashew tree.

Wavelength(in nm)	Healthy cashew tree	Infested cashew tree
666.75	**2.411**	**1.0097**
620.02	**0.8925**	**0.503**
586.05	**0.729**	**0.4315**

VI. Conclusion

Infestation by borer causes stress to the yielding cashew tree and lead to huge yield loss. Here the results are obtained by using spectroscopic methods and there is prominent change in the content of chlorophyll spectra Hence we have decided to propose the Portable embedded chlorophyll meter which farmer will be able to use without any expertise help.

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