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# Thermal Imaging as a potential element of Integrated Pest Management in Indian Agriculture

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**ABSTRACT**
*Thermal Imaging is a successful technology in the context of non-contact method of temperature measurement. Previously, this imaging system was successful in medical and military system and it has recently found successfully applicable to agriculture also. IPM is a sustainable approach to pest management, where all the methods are integrated together to check the pest population with minimum usage of pesticides. To support the successfulness of Integrated Pest Management, Thermal Imaging may be a potential element in identifying the density of pests and diseases. Using optical sensor technology is useful to identify foliar diseases like powdery mildew in barley, yellow rust in wheat, etc., but the thermal infrared radiation has the potentiality to identify not only the diseases but also its density and its associated pathogens with high spatial resolution. Pests like termites, rodents, etc can easily identified and checked. Thermal radiation is useful in weed management and it calculates the temperature of the leaves. Thermal imaging helps in identifying quality seeds by measuring its temperature. Water level of the plant as well as of the field can be measured by using thermal imaging. Though thermal imaging technology is a costly affair for now, in future with the research and development, the concept of thermal imaging can be implemented in agriculture. Though the cost of this technology seems to be more, the opportunity cost of this technology will replace the cost incurred by not using it. In near future the technology, which is going to rule agriculture, thermal Imaging will be a great example of new technology for a progressive agriculture. This paper reviews the need of thermal imaging to be an element of Integrated Pest Management in coming years for Indian agriculture.*
*Keywords: Thermal Imaging, technology, thermography, IPM, Agriculture*

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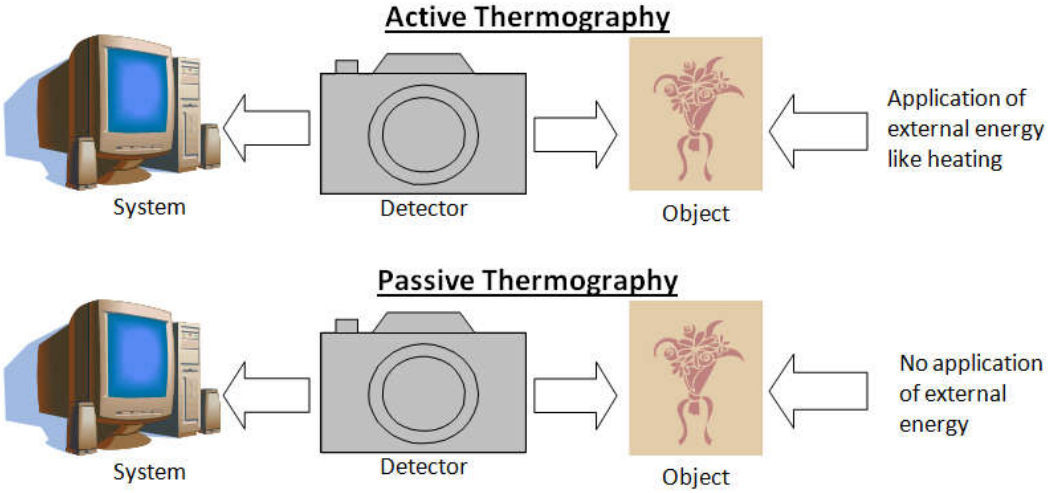
## INTRODUCTION

**Thermal Imaging:** Temperature has been an essential element in almost every industry. Temperature has become a parameter to identify, measure and check any tribulations. There are several conventional tools to measure temperature, such as, thermometer, etc. and out of which most methods are based on contacts. Every time the contact methods may not be successful. Recently, non-contact methods of temperature measurement have become successful like infrared thermography, x-ray, ultrasound imaging, microwave radiometry, and magnetic resonance imaging (MRI). So, non-contact method of measuring temperature has become an interesting phenomenon. Thermal Imaging is a successful technology in the context of non-contact method of temperature measurement. Both the active and the passive methods can be used in thermal imaging systems, where passive thermography uses no external energy and active thermography uses indirect application of thermal energy to the target, like heating, cooling, etc for the thermal information, as shown in figure 1.

**Figure 1: Active and Passive Thermography**




The system of thermal imaging systems has the components like camera, an optical system, detector array, signal processing and image processing system. Broadly there are two imaging system based on their ranges covered while imaging. These are middle wavelength IR (3-5 μm) and long wavelength IR (8-14 μm).There are various sub-types of active thermography, like Lock-in thermography, Pulse thermography, Pulsed-phase thermography and Vibrothermography. Generally, thermal images are grayscale in nature: black colour resembles cold, white resembles hot and the variation between the two is indicated by deep gray colour. With innovations, some thermal cameras add colours to different temperatures. Previously, this imaging system was successful in medical and military system and it has recently found successfully applicable to agriculture also.

**IPM in Indian Agriculture:** With the emergence of the Green Revolution, Indian agriculture had been able to hold its strength over years. Increasing use of pesticides was the only weapon to fight against subsistence farming. Around 15-25 percent of the crop produced is lost due to pests and diseases. ASSOCHAM articulates the crop loss per annum to be Rs. 50,000 crore. Insect pests, diseases, and weeds inflict enormous losses on the potential agricultural production. Evidence also indicates the rise in the losses, despite increasing use of chemical pesticides. Public concerns regarding the adverse effect of pesticides are rising. These negative externalities, though, cannot be eliminated all of a sudden; their intensity can be minimized through development, dissemination, and promotion of alternative technologies. As far as sustainability is concerned, Integrated Pest Management can be said as the future of sustainable pesticide market.IPM is a sustainable approach to pest management, where all the methods are integrated together to check the pest population with minimum usage of pesticides. According to FAO, "IPM is an ecosystem approach to crop production and protection that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides." The objective of IPM is to check the economic threshold limit and apply pesticides then only. Before ETL, there are several elements of integrated approach to cultivation, such as, cultural, mechanical and biological. IPM helps the farmers economically and helps the society at large as it is environment friendly. The recent case of whitefly outbreak at Malwa region of Punjab is an example of disadvantages of the injudicious use of pesticides. Many farmers committed suicides. Near about Rs. 4200 cr of loss occurred in cotton crop in this area despite of plant protection measures of Rs. 150 cr. According to Central Institute for Cotton Research (CICR), Nagpur, pink bollworm outbreak in cotton had made a vast damage to major cotton producing districts like Maharashtra, Andhra Pradesh and Gujarat. So, it can be said that the only use of plant protection agrochemicals cannot protect the agriculture. There is the need the integrated approach, which is IPM. Success stories of IPM are many, out of which some successful stories like Bayer India's crop science division had made successful project in Punjab and Haryana in case of cotton farming with guidance of CICR to effectively manage the whitefly outbreak in cotton. So, adaptation of IPM is needed. The problem lies in awareness and lack of interest. The field scouting, which is the major activity for identification of pest population periodically, is not known to farmers.

Identification of pests and diseases in field and better is identified by using thermal imaging.

**Thermal Imaging as an element of IPM:**To support the successfulness of Integrated Pest Management, Thermal Imaging may be a potential element in identifying the density of pests and diseases. Thermal Imaging will help the agriculture to be economic and time oriented. For simple operational procedure, there is the need of thermal imaging for both pre-harvest and post-harvest operations in agriculture. The potential use of this technology in agriculture includes identifying water requirement, detection of pests and diseases, and so on. This paper reviews the need of thermal imaging to be an element of Integrated Pest Management in coming years for Indian agriculture.

**Objective of the Study**

- To review the need of Thermal Imaging technology as an element of Integrated Pest Management

## METHODOLOGY

The research is based on secondary data. The information was taken from various sources like journals, research papers, etc. Discussion has been done based on the available secondary data.

## REVIEW OF LITERATURE

Giorleo andMeola [4] defined TI or infrared (IR) thermography as"a two-dimensional, non-contact diagnostic technique for measuring surface temperature of materials which can be usefully employed in non-destructive quality evaluation."

Maldague *et al.* [7] gave a broad classification of thermal imaging system into two types as active thermography and passive thermography. In Active thermography there is an external energy like heating or cooling is applied to the object while thermal imaging, while in the case of Passive thermography there is no external energy involved. They also gave different classification of active thermography as Lock-in thermography, Pulse thermography, Pulsed-phase thermography and Vibrothermography.

Rahkonen and Jokela [9] reported in their research that infrared technology is very useful for weed control. It measures temperature changes of leaves of plants efficiently. There may be errors in measurement because of incorrect estimates, inaccurate instrument and discrepancy of the signal. It was concluded in the research that, infrared radiometer is a superior instrument in measuring plant leaves' temperature and weed control. He also employed a formula to estimate the emissivity of a leaf, which is shown as below.

$$\varepsilon_t = \frac{(R_t - R_b)}{(R_r - R_b)} \times \varepsilon_r$$

Where $\varepsilon_t$ = emissivity of the leaf

$R_t$, $R_b$, $R_r$ = radiation emitted by leaf, background and reference, respectively

$\varepsilon_r$ = emissivity of the reference

Manickavasagan *et al.* [8] found thermal imaging very suitable in pre-harvest and post-harvest operations in agriculture. Many agricultural activities like scheduling irrigation, application of fungicides, herbicides, etc. can timely be done by thermal imaging.

Amon, *et al.* [1] reported that Infrared technology had been originally used in military purpose. Later it was used in fire service and other biological sciences with the advancement of computer technology.

Arora *et al.* [2] explained, during his study of infrared technology for breast cancer identification, that infrared technology is a non- destructive, non-contact and risk free system of temperature recording.

Bulanon *et al.*[3] revealed during their study that, variation of thermal temperature to fruit, leaves and branches was a potential approach to improve detection of fruits. They suggested a model for the estimation of total radiation received by camera, which is as below.

$$E_T = \varepsilon E_c + (1-\varepsilon)E_R + (1-\tau)E_A$$

Where$E_T$= the radiation emitted by fruit, leaves and branches

$E_R$= radiation from the environment

$\varepsilon$ = the emissivity of the fruit, leaves and branches

$E_A$ = the radiation emitted by the surrounding environment

$\tau$ = the transmittance of ambient surrounding.

Gowen *et al.*[5] reported the benefits of thermal imaging for fruits and vegetables. He found that thermal imaging is a highly potential technology for food quality and safety.

Ishimwe *et al.* [6] reported that thermal imaging is very fruitful in all sorts of agricultural activities like monitoring of nursery, scheduling of irrigation, stress detection of soil salinity, detection of plants disease, estimation of yield, evaluation of maturity and detection of bruise fruits and vegetables. Also, thermal imaging gives pictures of good resolution. He also added that the thermal imaging technology may not be universal in nature because of varied agro climatic zone.

## DISCUSSION

Using optical sensor technology is useful to identify foliar diseases like powdery mildew in barley, yellow rust in wheat, etc. But the thermal infrared radiation has the potentiality to identify not only the diseases but also its density and its associated pathogens with high spatial resolution. Thermal infrared is also proven to detect *pseudoperonospora cubensis* by which downy mildew in cucumber is caused. Thermal images have revealed that in the irrigated vines, the high the temperature the more is the chances of disease occurrences, while in the non-irrigated vines, less is the temperature more is the occurrence of the diseases. This technology helps in identifying the pests and its density. Pests like termites, rodents, etc can easily identified and checked. Thermal radiation is useful in weed management and it calculates the temperature of the leaves. Thermal imaging helps in identifying quality seeds by measuring its temperature. It has been found that seedling temperature is positively correlated with the degree of damage. Water level of the plant as well as of the field can be measured by using thermal imaging. The infrared radiation thermometer measures the temperature of the plants and the water level required for it can be shown easily through thermal imaging. If the stomata begin to close, the temperature of the plant and the canopy rise. The increasing temperature of the plant resembles the deficit of water level within the root zone of the plants. So, accordingly, the irrigation can be scheduled timely. Few researchers also found that thermal imaging is also estimation of yield. The damage of the output of agricultural production can also be measured by thermal thermography. So, if the benefits of thermal imaging integrated, then it will be very helpful to farmers. Infrared thermography can be an element of Integrated Pest Management in future. IPM is not that successful because of its awareness. Also it is a fact that thermal imaging technology is a costly affair for now. But in future with the research and development, the concept of thermal imaging can be implemented in agriculture. It can be done by initiating policies by subsidizing this technology. Farmers in India are getting exploited by different Multi National Companies. The farmers always are dependent on agri-input retailers and dealers for anything to purchase. Though the cost of this technology seems to be more, the opportunity cost of this technology will replace the cost incurred by not using it. Other costs like inspecting, applying pesticides blindly, loss of deficit or extra water in the field, etc can be minimized by implementing this technology. So, the government should take some initiative to promote this technology in near future.

## CONCLUSION

Thermal imaging is a very interesting concept, which has not started its journey. Still it is at infant stage worldwide because of its cost and awareness. This technology is not only helpful during pre-harvesting period but also in post-harvest period of agriculture. It helps in identifying the timing of irrigation, pest density, diseases associated, quality of seed, etc. So, with this technology the cost of other things can be minimized up to a greater extent. Though its cost seems to be high it has a higher opportunity cost in agriculture. Integrated Pest Management (IPM) may be more successful by adding this component because it also helps the farming in an integrated way. In near future the technology, which is going to rule agriculture, thermal Imaging will be a great example of new technology for a progressive agriculture.

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