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Electronic Trapping and Monitoring of Insect Pests troubling Agricultural Fields

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ABSTRACT

The impulsively fluctuating climatic conditions and the supplementary effects demand the protection of forestry and cultivation. Pests, bugs and insects are the vital issues that distress the development of crop. Eventually, monitoring and trapping of bugs becomes a more challenging task. The traditional human operators execute surveys of the traps dispersed over the field at regular intervals. This encompasses more work, requires considerable time and is not consistent. It is not effective on economic grounds too. These limitations in the existing systems call for automation with affordable cost.

Effective pest trapping will be highly favourable to the farmers while capturing and sending the images of pests will be helpful for further analysis in agricultural fields. Moreover, this will be definitely helpful in reducing the usage of pesticides since automatic trapping is efficient and effective. An electronic trap for pest insects by an autonomous monitoring system using black lights (Ultra Violet) and LED lights is suggested in this paper. A statistical analysis is made on the probable time of high pest population and a trap with three layers of different thickness is designed to capture various sizes of prominent pests. A low-cost image sensor is used to capture the images of trapped pests and the images are sent to a remote control station. The information thus acquired enhances the estimation of pest concentrations in farms. The entire analysis is carried out in paddy and brinjal fields and is supported by MSSRF (M S Swaminathan Research Foundation), Chennai.

Keywords: Pest management, electronic trapping, imaging sensing, autonomous monitoring, black lights, remote control, pest monitoring

INTRODUCTION

Agriculture is the base of our civilization and the vital food source of Asia (especially India) is rice. The vital parameters of rice such as size, volume and eminence are highly influenced by pest attack. There are varieties of pests which are damaging the quality of rice and the insects are available in different sizes. The degree of destruction in the paddy fields due to pest insects should be reduced and hence pest management becomes vital in agriculture. In fact, the supreme backbreaking task of farmers is pest control. There are multiple methods available for pest management in agriculture. Some of the methods discussed in literature are described here.

The pests and insects are attracted towards plants because they discharge volatile biological amalgams. Plants undergo various mechanisms by themselves for self-defence and their counter effect towards insects attack varies depending on multiple factors of damage. Hence, pest management becomes part and parcel of crop protection. Induced resistance is one of the popular tools used in insect management schemes. This analysis is much helpful in genetically designing the plants to produce sufficient and required self-protective compounds [1].

A scattered imaging device is added in pest control system which is functioned through a wireless sensing grid. This scheme includes a host station, master node and few client nodes. The part of trapped insects is captured as image and is transmitted to the host station. The station is equipped with reference insect density. If the original insect density exceeds the reference density an alarm is produced and communicated to client nodes through the master node. A zigbee transceiver is used to

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communicate the pest information among the nodes and the same is dispersed to farmers either through a message or call [2].Paddy fields are used to conduct experiments for exposing the pests. Water proof wireless camera which is safeguarded against direct sunlight is fitted in the field besides sticky traps. The image taken is pre-processed to enrich the existing image for effective investigation. The pixel sizes of consecutively apprehended pictures from the camera are used for sensing the pest. The images are compared till the change between reference image and captured image becomes void. The perceived object from the image is selected by scanning mechanism. The flat and perpendicular scanning of the image helps in identifying the coordinates and saving the final clear image [3].

Insects are easily attracted to Bluish-purple (UV) radiations because these rays are visible to insects. Yellow pan traps with yellow sticky plates are used to catch daylight insects. Lamps with yellow illumination are also used to control pest deeds during night. Thus, the extent of damage to flowers, vegetables and fruits can be controlled. The population of hovering bugs can be limited by covering the cultivated land using reflective materials [4].A real time checking system with insect counters and field servers is employed to monitor insects. Convectional fluorescent lights are replaced with bar coated by aromatic substance to attract a particular insect. A water resistant camera and Wi-Fi communication card are the salient features of field server which helps in image investigation and insect detection [5].Traditional sensor-nodes method of trapping insects is altered with modern web server enabled sensors for dynamic response. High-speed transmission is assured. Also, remote accessing of fields is effective by this method. An agent program is employed to assess the same and the investigational outcomes disclose the superiority of the offered method [6].

Field investigations by Indian Agricultural Research Institute, New Delhi at regular intervals were conducted for identifying and analysing the efficacy of diverse light sources in light traps used for checking numerous pest populations. Mercury lights, black lights and ultra violet lights were used for the investigation. Amidst the three light traps, Mercury light trap exhibited the maximum capability while Black light trap then UV light trap followed it [7].The data required for controlling the insect for a specific crop is multi-dimensional. Worth of the crop, the rudimentary features of the crop, three dimensional physiognomies such as longitudinal, latitudinal and altitudinal are indispensable for selecting a suitable method of insect control. The other vital evidence required for effective trapping is the drive pattern of insects. Thus, trap harvesting requires intense information than different approaches of pest control. The style and type of application decides the method of trap cropping [8].

A wireless sensor design is used to protect the fruit and vegetable crop in Australia from fruit fly. Machine vision methods are employed with fruit fly detection and recognition algorithm. The average precision of this system is experimentally found to be 80% [9].An image sensing network is developed and compared with ZigBee for checking the image transfer rate. The JPEG images are verified and the results reveal that the encoded images are more error resistant since the encoded images are having multiple layers [10].The efficiency of trap is dependent on the time of insect attacking and their location. Predicting them in manual trap is cumbersome. To increase the proficiency of the prevailing methods, a sensor is augmented and recording of insects is enabled. An insect noticing sensor encompassing a collection of phototransistors is designed. Infrared LED is employed for lighting these photo devices. The insects are detected using wing strokes and recorded. The information is communicated from the field to smartphone [11, 12].

CROP PRODUCTION IN INDIA

Many food crops are planted in India but rice is the major crop since it is preeminentcrop, and is the staple food of the people of the eastern and southernparts of the country. India is one of the world's largest producers of white rice and brownrice, accounting for 20% of all world rice production. Moreover, this country has the biggest area under ricecultivation, as it is one of the principal food crops. Rice is the most important and staple food crop for more than two third of population ofIndia and more than 65% of the world's population.More than 300 insectspecies are associated with the rice crop at one stage or the other. A statistical report on state wise rice production in India prepared by MSSRF is shown in Table 1. From Table 1, it is evident that sixty two million populations in Tamil Nadu is consuming rice as staple food. Controlling pest in rice crop by some effective method is hence essential. Considering the vegetative crops, brinjal is highly prone to be infected by insects than any other vegetables. So, suggesting an efficient methodology to control the pests in brinjal will be of greater help for the farmers.

Table1. *State wise rice production in India (Courtesy: MSSRF, Chennai)*

State	Total area (million hectares)	Area under rice cultivation(percentage)	Production (millionTons)	Population (millions)
Himachal Pradesh	6	20	1.2	6
Kerala	4	60	4.8	32
Rajasthan	34	20	6.8	56
Bihar	10	60	12.0	83
Karnataka	19	50	19.0	53
Haryana	4	80	19.2	21
West Bengal	9	80	21.6	80
Gujarat	20	60	24.0	51
Punjab	5	80	24.0	24
Madhya Pradesh	31	40	24.8	60
Tamil Nadu	13	70	27.3	62
Maharashtra	31	50	48.0	97
Uttar Pradesh	24	70	67.2	166
Andhra Pradesh	28	80	112.0	76

TIME ANALYSIS OF INSECT ATTACK

Many insects are plant feeders, and when the plants are of agricultural reputation, man is often enforced to strive with these insects. Insect populations are restricted by some factors such as uncomplimentary weather conditions, pillagers and parasites, and viral, bacterial, and fungal infections. Modern agricultural procedures providing fundamentally limitless food resources have eliminated some of these regulating factors. This has increased the rate of growth of attacking insects. Hence, the likelihood of incursions of specific insect pests is also increased.Almost all the crops are being infected by pests but finding the right time of attackfor individual crop is very much important to manage the pest. Table 2 shows the number of major insects attacking the crops at different time intervals. Studies reveal that the largest number of insects affecting agriculturalcrops is observed between the timings of 7 P.M. and 9 P.M.

Table2. *Number of insects observed at different time intervals (Courtesy: MSSRF, Chennai)*

Insect	6-7 P.M.	7-8 P.M.	8-9 P.M.	9-10 P.M.	10 P.M. - 2 A.M.	2-7 A.M.
Orthoptera Nemobiuscarolinus	549	592	332	338	563	124
Ephemeroptera Caenisdiminuta	1,123	81,655	76,349	592	19	64
Homoptera Cicadellidae	381	615	542	253	554	430
Antillocorispallidus	196	2,191	2,151	288	143	224
Trichocorixalouisianae	5,566	5,055	10,067	4,434	864	209
Coleoptera Aphodiinae	48	711	1,376	738	31	44
Carabidae	708	1,036	999	717	1,642	440
Pselaphidae	544	665	518	1,052	922	174
Staphylinidae	10,207	22,358	20,680	8,256	3,588	2,888
Dyscinetusmorator	187	541	380	149	34	12
Dytiscidae	2,435	3,112	2,001	2,773	785	335
Trichoptera Hydroptilidae	752	3,704	11,926	447	605	401
Macrotrichoptera	1,090	2,511	5,906	858	1,273	795
Lepidoptera Noctuidae	62	89	49	112	457	295
Pyralidae	2,998	2,991	2,054	2,764	5,888	2,410
Diptera Culicidae	190	224	705	161	301	213
Hymenoptera Formicidae	72	164	1,228	49	65	235

CONTROLLING METHODOLOGIES OF CROP ATTACKING INSECTS

Conventionally, insecticides had been used for controlling the insects. Though they provided good relief in combating the insects the quality of the yield was not effective. Moreover the fertility of the land was adversely affected. Nowadays, researchers are working towards natural farming to recover the quality of soil. So, controlling methodologies should not violate the quality of field and yield.

One of the simplest methods of pest control is growing a trap crop. It is an attractive host plant that draws attention towards it and keeps the insects away from the main crop all through the significant period of main crop. Pests and flies are greatly fascinated to reproductive phases of host plant than the vegetative phases. Trap cropping utilizes this concept to control the pests. Some of the advantages of trap cropping take into account the quality of yield, attraction of valuable organisms, enriching biodiversity and the reduction of usage of insecticides. However, this method does not provide a complete solution for all kinds of existing pest problems. Rather, an effective pest management requires expertise and the awareness of insect demeanors.

The next evolution in pest management is the use of insect traps they are used to monitor and reduce the insect populations by using baits such as food, visual lures, chemical attractants and pheromones. The trap mechanism or bait differs for different types of crops and insects. The food traps are intended not to harm any animals. The type of insects attracted by food trap may vary. Flies and wasps are attracted by proteins. Mosquitos and other insects are attracted by lactic acid, floral and fruity fragrances. Visual lures are of bright colours and different shapes. The intensity and colour of light is different for trapping different insects. Chemical attractants may attract only a particular sex. Light traps with or without ultra violet light attract certain insects. The number of insects attracted by these traps may depend on factors like temperature, humidity etc. Light traps can attract flying and terrestrial insects.A combination of light trap with other traps is being used to trap various insects. Sticky traps are used in indoor pest monitoring.

In the prevailing system of insect traps only ultra violet traps are used because most of the traps are UV sensitive. There is no modern image capturing techniques available in the existing systems. Also the present systems do not use timers or counters. Recording of visual information and statistical data are very much important in pest management. Hence a system is proposed to incorporate modern recording systems in this paper.

PROPOSED SYSTEM

In this paper, an autonomous monitoring system has been designed toimprove agricultural yield and reduce the effects of insect pests in hinderingproduction.Three different types of meshes are used (1 inch, ½ inch and ¼inch) and baits, namely Brown Sugar Yeast, Rotten fruits, Molasses andSugar water are placed on the meshes to lure the insects. Different types oflights like Ultra – Violet and LED are used to attract the insects and trapthem subsequently. Number of insects and species types can be identifiedand counted using the images obtained. IR Cameras are used for imagecapturing and GPRS/GSM module is used for intimation and datatransmission. The proposed design is shown in Figure 1.

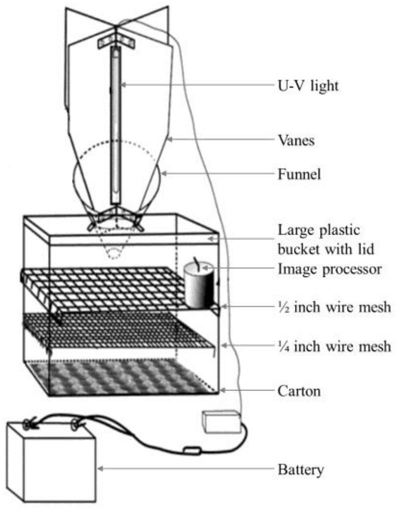

Figure1. *Proposed trap design (insect baits are used in each layer of the meshes)*

The materials used in the proposed design includes vanes (cardboard), wire mesh (1 inch, ½ inch and ¼ inch), plastic funnel, PVC sheets (for walls of the trap box), velcro, wires and insect baits. The major components used in the design are infra-red camera/web camera, Raspberry pi microcontroller, ballast, ultra-violet lamp, light emitting diodes, dc to ac inverter, 12v battery, solar panel (10w) and solar charge controller.

A thermo graphic infra-red camera with the wavelength as long as 14,000nm is employed in the model. Web camera can also be used to stream the captured image in real time or through a computer to computer network. The resolution of the image is of superior quality if a web cam used. For processing a Raspberry pi microcontroller equipped with USB/ethernet controller chip, 40 GPIO (general purpose input output pin), microSD card socket and dual step down power supply for 3.3V and 1.8V is used. A solar charge controller module is incorporated to stop charging the battery when they exceed a set high voltage level, and re-enable charging when battery voltage drops back below that level. The block diagram with the principal components is depicted in Figure 2.

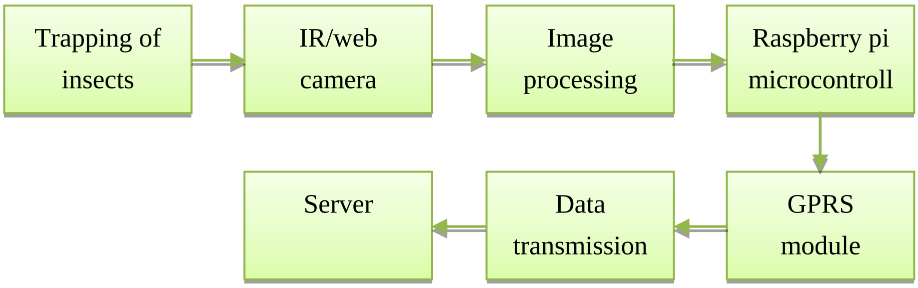

Figure2. *Block diagram with principal components*

EXPERIMENTAL SETUP AND RESULTS

The experimental setup was prepared using the materials and components specified in this paper in previous section. The final model will look like the one shown in Figure 3. For experimental and study and analysis 3 cases were taken viz., an open field, brinjal field and paddy field as suggested by MSSRF, Chennai. The open field was taken as a trial version and the same was incorporated in other considered fields.

Case 1 – Trap in an open field

The trap was placed in an open field in MSSRF, Chennai for a couple of days and the number of insects trapped were observed and the results are tabulated in Table 3.

Figure3. *Trap in an Open Field (Courtesy: MSSRF, Chennai)*

Table3. *Insects caught between 6pm and 9pm in an Open Field (Courtesy: MSSRF, Chennai)*

Insects caught	6 pm to 7 pm	7 pm to 8 pm	8 pm to 9 pm
Dragon fly	1	2	3
Cricket	2	3	4
Grasshopper	1	3	3
Flies	2	2	0
Bugs	1	3	1
Miscellaneous	2	2	3
Total	**9**	**18**	**15**

From table 3, it is observed that maximum number of insects trapped during the time interval 7-9P.M.

Case 2 – Trap in a brinjal field

The trap was placed in a brinjal field and the number of insects trapped was observed and the results are tabulated in Table 4. From table 4, it is witnessed that maximum number of insects trapped during the time interval 7-9P.M.

Figure4. *Trap in a Brinjal Field (Courtesy: MSSRF, Chennai)*

Table4. *Insects caught between 6pm and 9pm in a Brinjal Field (Courtesy: MSSRF, Chennai)*

Insects caught	6 pm to 7 pm	7 pm to 8 pm	8 pm to 9 pm
Dragon fly	0	2	1
Cricket	4	5	3
Grasshopper	3	7	5
Flies	0	2	0
Bugs	2	4	6
Miscellaneous	2	2	4
Total	**11**	**22**	**19**

Case 3 – Trap in paddy field

The trap was placed in a paddy field and the number of insects trapped was observed and the results are tabulated in Table 5.The image in Figure 5 shows the sample of insects trapped in three different layers of the suggested model. These images were captured through web cam which can be streamed in real time.

Figure5. *Sample insects caught in different layers of proposed designcaptured through web cam (Courtesy: MSSRF, Chennai)*

Table5. *Insects caught between 6pm and 9pm in a Paddy Field (Courtesy: MSSRF, Chennai)*

Insects caught	6 pm to 7 pm	7 pm to 8 pm	8 pm to 9 pm
Dragon fly	2	4	0
Cricket	3	7	9
Grasshopper	4	6	11
Flies	0	3	1
Bugs	3	5	7
Miscellaneous	3	4	2
Total	**15**	**29**	**30**

It is evident from the Table 5 that maximum number of insects trapped during the time interval 7-9 P.M.

CONCLUSION

A statistical analysis is made about the harmful pests in agricultural field along with their pertinent time attack. An insect trap is modelled with three different layers with different thickness to catch the different size of insects and appropriate bait is spread over the layers to attract the insects. An autonomous monitoring system using black lights (Ultra Violet) and LED lights is ensuredwith a low-cost image sensor to capture the images of trapped pests. A solar panel of 10W is used to charge the battery to power the LED and the UV lights. The power generated through solar panel is stored in a battery for operating the system during night. A solar charge controller guarantees effective charging of the battery and enhances the life of the battery. The captured images are sent to a remote control station. The information thus acquired is used for the estimation of pest concentrations in farms. The experiment is carried out by placing the designed trap in three different fields.

The insect disposable electronic trap captures images of the collectedinsects and sends the real-time insect pests images to the server of MSSRF, Chennai according to the periodicity required. Theimages are studied by theEntomologists of MSSRF to get information about the insect species anddensities present in the agricultural fields. Therefore, using the collectedinformation, MSSRF can suggest farmers to use appropriate pesticides andinsecticides for their crops. This reduces the effects of harmful chemicals onsoil and hence improves the soil quality without compromising on the yield. The scope of the project can be expanded by adding the concept ofelectrocution. This can be done by changing the existing meshes intoelectrocuting meshes to kill the collected insects, which is preferred byfarmers over killing agents. Hence, the walls of the trap can be designed for better insulation.

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