International Journal of Engineering Technology, Management and Applied Sciences

IJETMAS

www.ijetmas.com April 2015, Volume 3 Issue 4, ISSN 2349-4476

Modelling and Optimization of Solar Light Trap For "Reducing and Controlling" The Pest Population

L.Harsha Vardhan Reddy 11W51A0322
V.Ashok Kumar Reddy 11W51A0348
S.Hemanth 11W51A0327
P.J.Durga Prasad 10W51A0333
Under Guidance of
M. Rama Narasimha Reddy and Ammika Srinivas Goud
Department of Mechanical Engineering, SVTM (J.N.T.U.A)
Angallu, Madanapalli ,Chittor (Dist), A.P., India

Abstract

"Reducing and controlling the pest population using light traps is an age old practice in our crop sector. Though there are several models and designs are available but we would plan to develop something that could be solar powered trap with collecting net and not dependent on any other source like wind power, mechanical power, fuel & electricity. This device operates automatically, turning on the light during light fails i.e., 6 P.M and turns off before sunrises i.e., 6A.M. Most of the damage causing insects are active only during that time. Installing one light trap in an acre attracts at least more than 1000 adult pests for a day. The insects attract solar light trap model "had been tested in our field crops like vegetables, paddy, and sugarcane, fruit crops like mango, pomegranate, guava, coconut and tea, coffee and jasmine crops across INDIA.

In this study we examine the relationship between the Lunar Phases and the efficiency of light traps in catching pests in the month of March and April at Madanapalli, Chittor , Andhra Pradesh. The lunar phase depending on the polarized moonlight and the relative catch follow the collecting distance. The collecting distance ranged and averaged in the phase angle divisions. The study demonstrated for the first time the effect of increasing polarized moonlight in the first and last quarter on the flying activity of pests. Catching quantity depend on the connection with the collecting distance when is the greatest of collection distance.

1. Introduction

Water, land, formers and living things (including humans) benefit from the reduction of harmful pesticides. The goal of reducing pesticide use is to create a better environment and provide a long term resource for farmers.

Agriculture is a principal occupation for farmer. Every year farmers face pest problems which seriously destroy crops. There are many preventions and exterminations of pest problems, such as mechanical method, physical method, biological method, and chemical method. Using pesticides and chemical method directly affects on agriculturists and consumers, for example, pests are chemical resistant which leads farmers using more and more pesticides. This causes plant residue which is dangerous for consumers, and also affects on environment and ecology. Moreover, agriculturalists has tried to find other ways instead of chemical used such as using lights to tempt pests which is popular way for farmers. However, that way is still lack of electric energy for bulbs because the farm is far away, and trap is also expensive. From this point, we have developed

Solar Energy based Insect pest trap for orchards, vegetable, tea plantation and for any cultivation.

Alternative pest control practices reduce or eliminate the use of pesticides. These ecological options improve the surrounding land and livelihood of farmers by eliminating the dependency on toxic insecticides, promoting local markets, and reducing food poverty by creating a long term food source. These agro ecological practices have shown to cost less for farmers than conventional practices, and in some cases, they cost nothing. It is important to promote the use of alternative methods of pest control. "Insects often evolve resistance to insecticides within a decade". Also, insufficient diversity of crops can increase risks of pests. Pesticides make it possible for high yields to be produced in one growing season. This artificial boost to the crop does not help replenish nutrients in the soil, and ultimately leads to a decrease in output.

Nowadays there are many ways to destroy insect and reduce damages from pest. Insect and pest control is necessary for agriculturists to solve the problem. Farmers use many ways of conventional techniques with insects and pests such as, Biological Alternatives, Non Biological Alternatives, Plant Resistance, Cultural Methods, Mechanical and Physical Methods, Legal Control, Chemical Control, Integrated Pest Control, Natural or Organic Farming

To overcome those conventional pest destroy method we have one step ahead and derived a solar light trap. it is an electronic device using the photo taxis (light rays) and chemo taxis (energy trap) to induce pests to touch the high-voltage power grid, thus killing or collecting them in bag. It has become one of the primary means to control the insect attack. The pest control LED lights could effectively reduce the dosage of pesticides as well as their pollution on the agricultural products, soil and water. The solar LED light is easy to use and can be applied to various crops. The solar LED pest control light is mainly composed by solar panels, batteries, control circuit, control keyboard, LED lamps, boost circuit, high-voltage grid, sensor and bracket and other components. During the day, energy from the solar panels will be stored in the storage batteries at night, the electrical energy from the battery could drive circuit of LED light to control pest.

The light-trap is the most commonly used sampling device to study the pests of flight characteristics. However, the effectiveness of light-trapping as an insect sampling method was influenced by many environmental variables from meteorological to cosmic factors. Illuminations are the most known environmental factors influencing the light trap collection of caddis flies. Several investigations were carried out to measure the effects of various weather variables, like precipitation, wind speed, cloud cover, relative humidity, or night air temperature. The other studies reported increasing captures of light-traps during full moon, a phenomenon that should reflect an increased insect activity in some cases. The possible moonlight effects on insects sampled by light trapping. On account of polarized moonlight and perhaps polarization pattern of the night sky, many aquatic insects are also able to detect their habitats by the perception of linearly horizontally polarized light reflected from the water Surfaces. If the insects are able to navigate by the polarized moonlight, it cannot limit the collection of light-trap. The collection radius may influence the catch level only if the environment is free of light pollution and when the collected species are able to fly larger distances.

2. Design of experimental set up

This system is mainly constituted by solar panels, super capacitors, control circuit, control keyboard, LED pest control light sensors, Trapping net, one body type bolt, fan, and leg support base as shown in Fig.1 and Fig.2. The function of solar panels is to convert the solar radiant energy to the electrical energy which is then stored by the super capacitor for the load to use, the control circuit is the core of the solar LED pest control system, for the charge and discharge control will directly affect the system's application results, so the charge and discharge controller should have various functions such as the charge and discharge, the maximum power tracking, overcharge protection, over-discharge protection, short circuit protection etc.

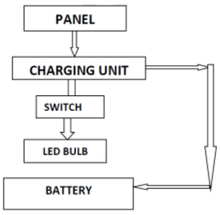


Figure 1: The schematic diagram for solar trap pest controller

Figure2: Solar trap pest controller

2.1 Design of solar panel

The solar radiation in kadapa is greater in summer and less in winter and the annual average sunshine hours are fewer. The insect activities are for feeding and mating, so their intense movement makes the evening as the best time to trap them. Therefore, the LED pest control light is required to work for 10 h - 11 h in the evening (from 6 p.m to 6 a.m). Based on the above factors, the minimum solar panels are determined the polycrystalline silicon solar panel with the output power of 25W±3%, the output current of 1.39 A, the short-circuit current of 1.64 A, the open circuit voltage of 22 V, the output voltage of 18 V and the size of 410×410×30 mm.

2.2 Design of LED light

Based on the sensitive wavelength range of most of the pests with photo taxis, LED is selected as the light source. Carry out superimposing light distribution and utilize the photo taxis and chemo taxis of the target pests to attract and kill pests

2.3 Design of fan and Trapping net

The Eradicator (sucking) trap (fan) is shaped to attract insects from a specific area rather than from all around you, so you can eliminate insects from your immediate area. Other traps are designed to fight insects in all directions. The fans shown in figure 3, is having powerful vacuum, with combined optimal airflow design to draw insects into mess (net) collection chambers where they rapidly dehydrate and die. It is designed on basis of design value of 1,200~1,500rpm low speed to high-flow rate suction, designed for safety . it is run by the - DC power source.

Figure3: Design of solar trap fan for suck the pests

Figure4: Design of solar trapping net for storing the pests

Light+ fan+ attractant is called trapping net or attached trapping cage as shown in figure 4.it is just like mosquito net. it is made with small diameter of wire and it is having capability to store 10 days of pests. It is flexible to open and close and remove the pests.

2.4. Design of control unit

The solar LED light for killing pests is mainly composed of the solar cell panel, the lead acid battery, the LED light, the high voltage fence, the control system and the mechanical components.

3. Design parameters of solar trap

Solar panel	18V/25W
Auto control	DC 12V (No danger of short circuit, electric shock, and lightning)
Battery	DC 12V, 4.5A, Rechargeable battery
Fan	1,200~1,500rpm low speed high-flow rate suction designed for safety
Lamp	DC 12V 3W
Weight	Approximately 17kg (Packaging)
Dimension	Main Body: 545mm X 510mm X 390mm, Net Length 550mm
Coverage	320~500㎡/ 1 Unit
Type of product	Eco friendly
Type of energy	Solar energy
Weight	6.6kg
Weight of lamp a djustable stand	2.7Kg
No of legs	3
Angle of each leg	120
Height of leg from ground	3 m
Battery charging hours	10 to 12
Set up working area	0.75 acre
Set up working hours	6 pm to 6am
Type of moment	Flexible
Type of colour	White

4. INSTALLATION

When we install the pest control lights in the field installation, if the distance between lights is greater than the radiation range, it may result in inadequate pest trapping, if the distance between lights is smaller than the radiation range, it may lead to resource waste. Set different light distances according to the experiment to conduct trapping, and then identify the appropriate one by the comparative analysis. Since the natural distribution of most of the insects is aggregated distribution in a small-scale range, the trapping experiment should be carried out in the large range to ensure the uniformity. Record the number of the insects and number them, drying them for preservation. Average the dry weight of insects respectively collected under two light distances and then map by date. By comparing the number of insects under different light distances, find the reasonable one.

The light intensity is related to both the distance and the installation height. Theoretically speaking, the higher the position of the light source is, the farther the light propagation will be, coupled with more obstacles and more trapping insects. This is appropriate for the smaller insects. However, for the big insects, it is difficult to achieve trapping when they fly too high, so there is no need to install the light source too high for these kinds of inspects.

4.1 .How do solar panels work?

Solar panels collect solar radiation from the sun and actively convert that energy to electricity. Solar panels are comprised of several individual solar cells. These solar cells function similarly to large semiconductors and utilize a large-area p-n junction diode. When the solar cells are exposed to sunlight, the p-n junction diodes convert the energy from sunlight into usable electrical energy. The energy generated from photons striking the surface of the solar panel allows electrons to be knocked out of their orbits and released, and electric fields in the solar cells pull these free electrons in a directional current, from which metal contacts in the solar cell can generate electricity.

Objectives

✓ It is a solar chargeable and automatic timer device Turn ON by sunset and Turn Off after sunrise, it is a continuous operation.

- ✓ No Electricity and Manpower required to operate the device.
- ✓ Economical and helps reduction of chemical pest management cost.
- ✓ Eco friendly Pest and Insects Control device.
- ✓ Manufacturing cost is also low.
- ✓ It can be place at anywhere because it occupies less space.
- ✓ It is easy to carry due to less weight.
- ✓ It doesn't harm to environment

4.2. Moon effect to collect pests

To create data lunar and full moon phase divisions, we downloaded temporal data on Full Moons from the website of the Astronomical Applications Department of the US Naval Observatory (http:// aa.usno.navy.mil/cgi-bin/aap ap.pl). Data on the rising and setting of the full Moon and lunar phases were downloaded from: http://aa.usno.navy.mil/cgi-bin/aa_pap.pl. The mean revolution time of the moon on its orbit around the Earth is 29.53 days. This time period is not divisible by entire days, therefore we rather used phase angle data. For every midnight of the flight periods (UT = 0 h) we have calculated phase angle data of the moon. The 360° phase angle of the complete lunation was divided into 30 phase angle groups.The phase angle group including the full moon (0º or 360º) and ± 12º.

Beginning from this group through the first quarter until a new moon, groups were marked as -1, -2, -3, -4, -5, -6, -7, -8, -9, -10, -11, -12, -13 and -14. The next division was ±15, including the new moon. From the full moon through the last quarter to the new moon the phase angle groups were marked as 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14. Each phase group consists of 12° .

These phase angle groups are related to the four quarters of lunar cycle as it follows: full moon (-2 to +2), last quarter (3 to 9), new moon (10 to -10) and first quarter (-9 to -3). Because the increasing moonlight intensity can decrease the catching radius of a light-trap, the required illumination of the moon corresponding to each night of moon phase angle divisions.

4.3. Polarization of Moonlight

As the proportion of polarized moonlight is highest in the First and the Last Quarters, we had to determine whether pests can see the Moon in these lunar phases in order to be able to examine the influence of polarized moonlight. In the First Quarter they obviously can, as on these days the Moon is visible in the evening, but in the Last Quarter, in most cases only after midnight. Therefore, based on data on the rising and setting of the Moon in the period close to the Last Quarter, we determined whether each flight occurred only if the Moon was above the horizon before midnight, the period when this species is active.

4.4. Collecting Distances

With the help of environmental illumination components by the following formula, we have calculated environmental illumination every night for 11 p.m. which operated in the light traps. From the environmental illumination values we have calculated theoretical collecting distances, assigning our catch data to these.

We calculated the collecting distance values for the all phase angle divisions. We have sorted relative catch values into the proper phase angle divisions. We have arranged data regarding phase angle divisions together with the relating relative catch values into classes.

The number of these classes was calculated with consideration to the method, the theoretical collecting distance can be calculated using the following formula

$$r_0 = \sqrt{\frac{I}{E_S + E_M + E_{SS}}}$$

www.ijetmas.com April 2015, Volume 3 Issue 4, ISSN 2349-4476

Where: r_0 = collecting distance,

I = illumination from the bulb of trap,

E_S= the illumination coming from the environment consisting of the light of the setting Or rising sun

E_M = illumination of moon,

E_{SS} = starry sky

The data thus obtained are tabulated. We determined that the expected value (1) in which Moon Quarter is significantly higher or lower relative catch value. If in the First or Last Quarter was found high-value relative catch we were looking relationship with the polarized moonlight values, in case of New Moon, with the collection distance.

We have sorted relative catch values into the proper phase angle divisions and averaged them. We depict the results and indicate the regression curve, its parameters and the significance levels in the figures..

In addition, for the full moon to lunar section of each month we analysed the correlation between the adapting pests with all considering factors. Same way we examined the relationship between the illumination from the bulb of trap, the illumination coming from the environment consisting of the light of the setting or rising sun (ES), the moon (EM), and the starry sky with the collecting distance. A point moving average of relative catch values and the theoretical collecting distance. In every case we calculated significance levels for the correlation coefficients. The results were plotted on graphs.

4.5. Calculation methods and Graphs

1st Phase angle= -15

The theoretical collecting distance Formula as given by $r_o = \sqrt{\frac{I}{E_E+E_M+E_{SS}}}$

$E_E = 0.0012, E_M = 0.179, E_{SS} = 0$

$r_0 = \sqrt{\frac{150}{0.0012+0.179+0}}$ = 28.85

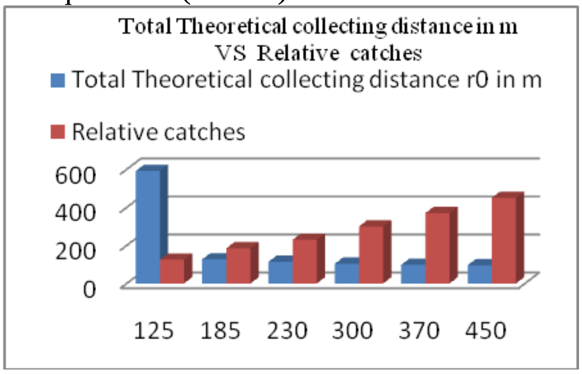
Here similarly we have calculated the relative catch values from solar power trap on pests which are roaming around crop field. The basic data were collected on the number of individuals caught by one trap in one night. The number of basic data exceeded the number of sampling nights because in most collecting in the month of March and April operated synchronously.

In order to compare the differing sampling data of a species, relative catching values were calculated from the number of individuals. For each examined species the relative catch (RC) data were calculated for each sampling day in those months. The relative catch was defined as the quotient of the number of individuals caught during a sampling time unit (1 night) per the average catch (number of individuals) within acre ,therefore we listed average collecting no of pests count in 30 days dropped in the table 1.

4.6 Waxing Crescent Graphs

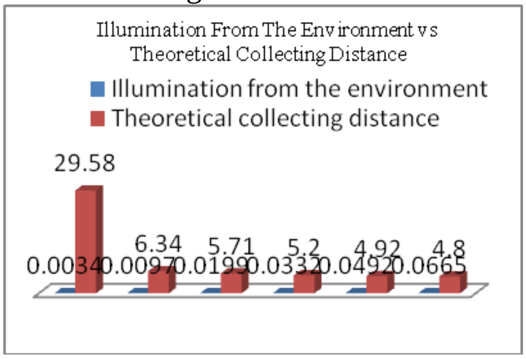
Change in the relation between total theoretical collecting distance and relative catches in Waxing Crescent in lunar phase angle -14 to -9 and moon range angle 174 – 102.

First quarter = (-9 to-3)



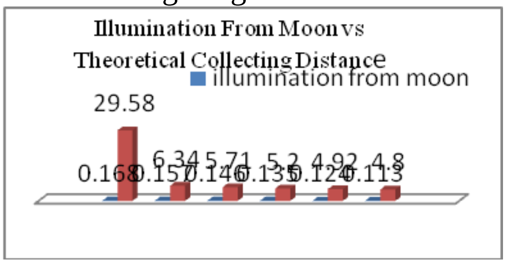
Graph1: Total theoretical Collecting Distance vs Relative Catches

Change in the relation between illumination from the environment and theoretical collecting distance in Waxing Crescent in lunar phase angle -14 to -9 and moon range angle 174 – 102.



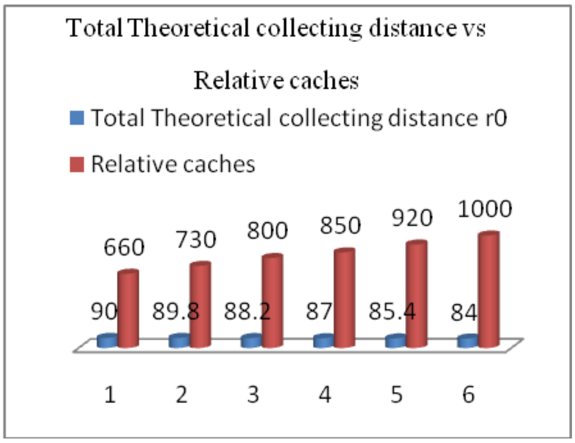
Graph2: Illumination From The Environment vs Theoretical Collecting Distance

Change in the relation between illumination from moon and theoretical collecting distance in Waxing Crescent in lunar phase angle -14 to -9 and moon range angle 174 – 102.

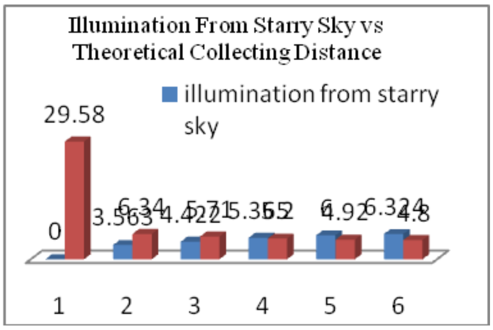


Graph3: Illumination From Moon vs Theoretical Collecting Distance.

Change in the relation between illumination from starry sky and theoretical collecting distance in Waxing Crescent in lunar phase

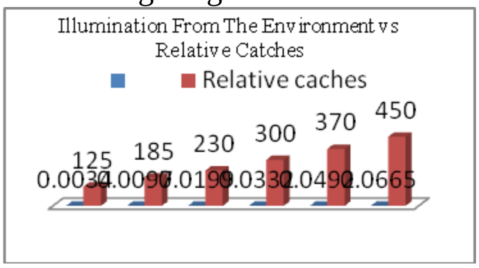


angle -14 to -9 and moon range angle 174 – 102.



Graph4: Illumination From Starry Sky vs Theoretical Collecting Distance

Change in the relation between illumination from the environment and Relative Catches in Waxing Crescent in lunar phase angle -14 to -9 and moon range angle 174 – 102.

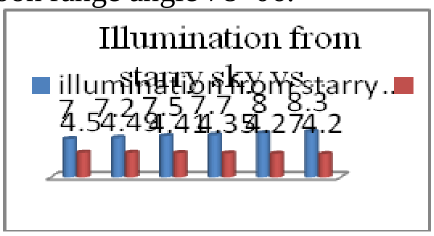


Graph5:Illumination From The Environment vs Relative Catches

4.7. Waxing Gibbous Graphs

Change in the relation between Total Theoretical

Collecting Distance and Relative Catches in Waxing Gibbous in lunar phase angle -6 to -1 and moon range angle 78–06.



Graph5:Illumination From The Environment vs Relative Catches

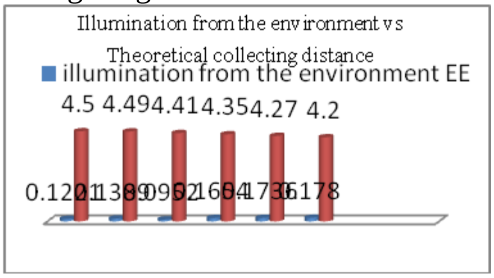
S. No	Moon angle range	Lunar phase angle	Quadrant	Blub illumination	illumination from the environment E_E	illumination from moon E_M	illumination from starry sky (Polarized Moonlight %) E_{SS}	Theoretical collecting distance r_0 in m	Fan speed In rpm	Total Theoretical collecting distance r_0 in m	Relative caches
1	186-174	±15	180	150	0.0012	0.179	0	28.85	20	577	63
2	174-162	-14	Waxing Crescent	150	0.0034	0.168	0	29.58	20	591.6	125
3	162-150	-13		150	0.0097	0.157	3.563	6.34	20	126.8	185
4	150-138	-12		150	0.0199	0.146	40422	5.71	20	114.2	230
5	138-126	-11		150	0.0332	0.135	5.365	5.20	20	104	300
6	126-114	-10		150	0.0492	0.124	6	4.92	20	98.4	370
7	114-102	-9		150	0.0665	0.113	6.324	4.80	20	96	450
8	102-90	-8	90° = First Quarter	150	0.0854	0.102	6.576	4.704	20	94.08	523
9	90-78	-7		150	0.1041	0.091	6.285	4.611	20	92.22	590
10	78-66	-6	Waxing Gibbous	150	0.1221	0.08	7	4.5	20	90	660
11	66-54	-5		150	0.1389	0.069	7.2	4.49	20	89.8	730
12	54-42	-4		150	0.0952	0.058	7.5	4.41	20	88.2	800
13	42-30	-3		150	0.1654	0.047	7.7	4.35	20	87	850
14	30-18	-2		150	0.1736	0.036	8	4.27	20	85.4	920
15	18-06	-1		150	0.178	0.025	8.3	4.20	20	84	1000
16	6-354	0	0° or 360° = Full Moon	150	0.1791	0.012	9	4	20	80	1000
17	354-342	1	Waning Gibbous	150	0.1772	0.025	8.3	4.2	20	84	920
18	342-330	2		150	0.1713	0.036	8	4.27	20	85.4	850
19	330-318	3		150	0.1618	0.047	7.7	4.35	20	87	800
20	318-306	4		150	0.1497	0.058	7.5	4.4	20	88.2	730
21	306-294	5		150	0.1345	0.069	7.2	4.5	20	90	660
22	294-282	6		150	0.1181	0.08	7	4.56	20	91.2	590
23	282-270	7	270° = Last Quarter	150	0.1001	0.091	6.285	4.811	20	96.22	523
24	270-258	8		150	0.0825	0.0102	6.576	4.71	20	94.2	450
25	258-246	9	Waning Crescent	150	0.0646	0.113	6.324	4.803	20	96.06	370
26	246-234	10		150	0.0475	0.0124	6	4.9	20	98	300
27	234-222	11		150	0.032	0.135	5.365	5.22	20	104.4	230
28	222-210	12		150	00.0193	0.146	4.422	5.72	20	114.4	185
29	210-198	13		150	0.0097	0.157	3.563	6.34	20	126.8	125
30	198-186	14		150	0.0033	0.68	0	29.59	20	591.8	63
	186-174	±15	180° = New Moon					29.59			

Table2: Design Calculations between Moon Effect

www.ijetmas.com April 2015, Volume 3 Issue 4, ISSN 2349-4476

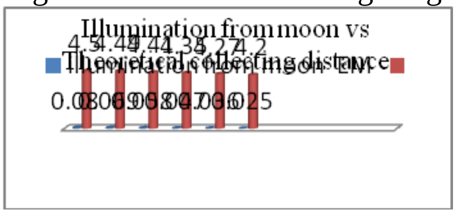
Note: Phase angle groups of moon quarters: Full moon = (-2 to 2) Last quarter = (3 to 9) New moon = (10 to -10 Angle and Relative Catches

Change in the relation between Illumination From The Environment and Theoretical Collecting Distance in Waxing Gibbous in lunar phase angle -6 to -1 and moon range angle 78–06.



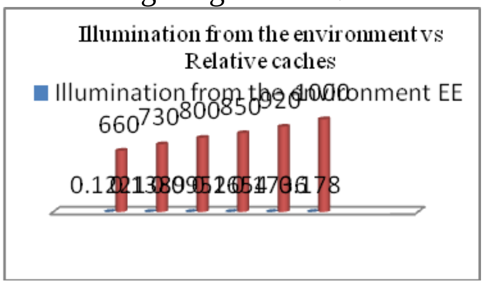
Graph6: Illumination From The Environment vs Theoretical Collecting Distance

Change in the relation between Illumination From Moon and Theoretical Collecting Distance in Waxing Gibbous in lunar phase angle -6 to -1 and moon range angle 78–06.



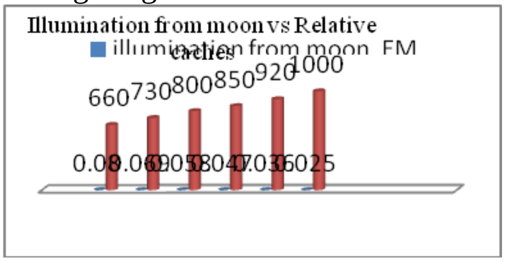
Graph7: Illumination From Moon vs Theoretical Collecting Distance

Change in the relation between Illumination From The Environment and Relative Catches in Waxing Gibbous in lunar phase angle -6 to -1 and moon range angle 78–06.



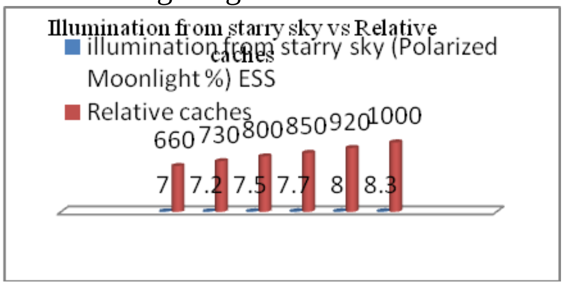
Graph8: Illumination From The Environment vs Relative Catches

Change in the relation between Illumination From moon and Relative Catches in Waxing Gibbous in lunar phase angle -6 to -1 and moon range angle 78–06.



Graph9: Illumination From Moon vs Relative Catches

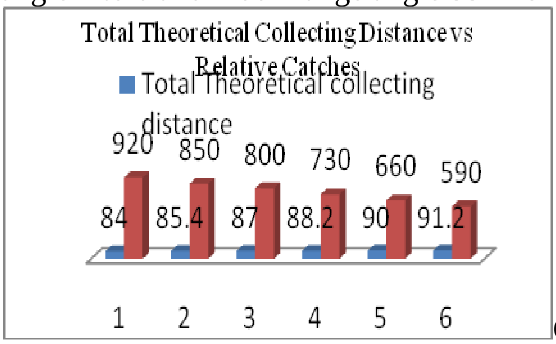
Change in the relation between Illumination From Starry Sky and Relative Catches in Waxing Gibbous in lunar phase angle -6 to -1 and moon range angle 78–06.



Graph10: Illumination From Starry Sky vs Relative Caches

4.8. Waning Gibbous Graphs

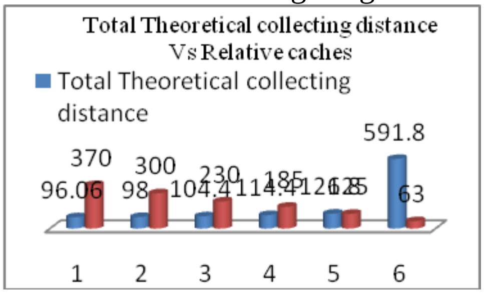
Change in the relation between Total Theoretical Collecting Distance and Relative Catches in Waning Gibbous in lunar phase angle 1 to 6 and moon range angle 354-28



Graph11: Total Theoretical Collecting Distance Vs Relative Catches

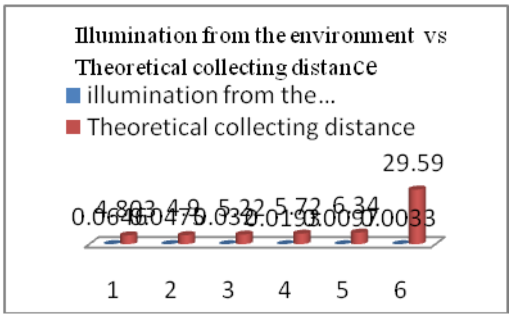
4.9. Waning Crescent graphs

Change in the relation between Total Theoretical Collecting Distance and Relative Catches in Waning Crescent in lunar phase angle 9 to 14 and moon range angle 258-186.



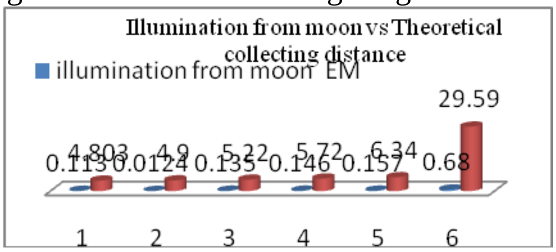
Graph12: Total Theoretical Collecting Distance Vs Relative Catches

Change in the relation between Illumination From The Environment and Theoretical Collecting Distance in Waning Crescent in lunar phase angle 9 to 14 and moon range angle 258-186.



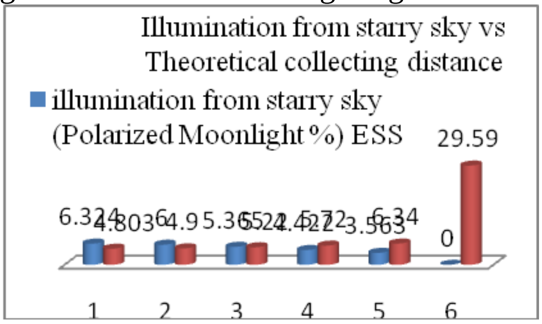
Graph13: Illumination From The Environment Vs Theoretical Collecting Distance

Change in the relation between Illumination From Moon and Theoretical Collecting Distance in Waning Crescent in lunar phase angle 9 to 14 and moon range angle 258-186.



Graph14: Illumination From Moon vs Theoretical Collecting Distance

Change in the relation between Illumination From Starry Sky and Theoretical Collecting Distance in Waning Crescent in lunar phase angle 9 to 14 and moon range angle 258-186.



Graph15: Illumination From Starry Sky vs Theoretical Collecting Distance

5. Results

- ✓ Relative catch data of pests depending on the phase angle divisions can be seen in Table2. This Table shows the significance levels of Moon Quarters and the light-trap catch of examining pests.
- ✓ Except some of pests which are not relative to solar trap (whose are beside of trap), the catching of all the other pests can be observed in the First and Last Quarter.
- ✓ The catching pests of 100 are in First Quarter, another 50 pests are have the peak in the First Quarter and Last one, and only 100 are in is in Last Quarter. This fact in these Moon Quarters attributes to the high polarized moonlight.
- ✓ Experiencing a peak in the Last Quarter can be partially explained by the fact that a higher percentage of the polarized moonlight in Last Quarter and in the First Quarter

6. Discussion or conclusion

- ✓ Under the sunny days, the moonlight will reduce the trap quantity and the full moon and new moon respectively has the greatest and least influence. Therefore, during the days with high winds, rainfall and full moon, the pest control light can be turned off. It is necessary to set a reasonable opening and closing time, which could save energy, extend its service life and reduce the damage to these non-target insects.

- ✓ With the growth in the living standard, it is necessary to supply a large number of environmentally friendly green agricultural products.
- ✓ Another reason may be that in Hungary during the summer months a long time can be seen the Moon in the Last Quarter as the First Quarter. This feature will only cover to those species that can fly also in the second half of the night.
- ✓ These species are capable of "use" the large collection distance by using fan. This means that they can fly and respond to the light stimulus from this distance. Probably the polarized moonlight is likely to be less important for the most of pests.
- ✓ However, in this Area of project there is extremely high light pollution. Consequently, the collection distance has a little difference between each other.

The Moon is staying above the horizon in First Quarter in the evening and in the Last Quarter after midnight. Catching few of pests only are connection with in the collecting distance.

Until now, there are few researches on it at India, abroad and all over world, so it is of great importance to study its influence on the pest control of agricultural products and provide pollution-free agricultural products. We think that further studies are necessary to clarify the cause of the minimum catch during the Full Moon.

7. References

1. H.R. (1972). Sensory response of the compound eye of adult Heliothis zea and H. virescens to ultraviolet stimuli. Ann. Ent. Soc. Am., 65: 701-705.
2) Baker, R.R. (1979). Celestial and light-trap orientation of moths. Antenna, 3: 44-45.
3) Baker, R.R., Sadovy, Y. (1978). The distance and nature of the light-trap response of moths. Nature, 276:818-821.
4. Bonada, N., Zamora-Muñoz, C., Rieradevall, M., and Prat, N. (2004) Trichoptera (Insecta) collected in Mediterranean river basins of the Iberian Peninsula: taxonomic remarks and notes on ecology. **Graellsia**, 60, pp. 41-69.
5. Bowden, J. (1973), The significance of moonlight in photoperiod responses of insects. **Bulletin of Entomological Research**, 62, pp. 605-612.
6. Cinzano P, Falchi F and Elvidge C D. 2001. The first world atlas of the artificial night sky brightness. Mon. Not. R. Astron. Soc.**328**: 689–707.
7. AMBRUS A. & CSÓKA GY. 1988: Investigations on the swarming of winter moth (Operophthera brumata L.) by the aid of pheromone traps. Erdészeti Kutatások **80–81**: 167–172 [in Hungarian].