International Journal of Humanities and Social Science Invention
ISSN (Online): 2319 – 7722, ISSN (Print): 2319 – 7714
www.ijhssi.org ||Volume 6 Issue 2||February. 2017 || PP.42-49

Alternative Control of Insect Pests Using Paper in Corn Plants

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ABSTRACT: *Vegetables are a very important source of food for humans due to their nutritious content such as fibre, vitamins, and minerals. In meeting people's demand of vegetables, farmers have to deal with a number of obstacles, one of which is the problem caused by insect pests. A number of measures have been undertaken by farmers to control the insect pests. The aim of this research was to test the insect trapping devices made of coloured paper and lights. The colours tested were red, yellow, and green. This research was conducted from July to August 2016 in the experiment garden of SekolahMenengahKejuruan PembangunanPertanian (SMKPP), LembahSeulawahSub-district, Aceh Besar District, Aceh Province. The object of the research was corn plants.The method used wasRCBD with 3 treatments and 4 replicates. The observation variable was the insect population trapped in the coloured paper and lights. The finding of this research revealed that the yellow paper and light trapping devices captured the highest number of insects, followed by the paper and light traps of green and red colours.*

Keywords: *Alternative control, coloured traps, vegetables.*

I. INTRODUCTION

Insects are a dominant group of animals which constitutes 80% of all animals existing on earth (Borror, 1987). It is for this reason insects can survive in various habitats, have a high reproductive capacityas well as anability toutilize different types of food sources and to escapetheir predators (Kalshoven, 1981).

Insects live in an agricultural ecosystem continuously because it enables them to obtain sufficient, if not abundant, food.According to Andrewartha and Birch (1961),ecosystem is a system formed by a dynamic interaction between abiotic and biotic components.Therefore, an ecosystem can be defined as a complex and interactive unit comprising all organisms living in a certain physical environment.Based on the above definition, it can be deduced that pest control requires an analysis of system interaction up to the level of ecosystem(Kasumbogo, 1984).

Using coloured paper and light as an alternative pest control is a natural way of physically attracting insects. Every type of insects has different adaptation abilities in order to protect themselves from predators. This research aimed to find alternativesin insect pest management and to reduce the use of chemical insecticides. Insects'interest in colourscan be used asa control measure as previously mentioned in a number of literature.There are many ways to get insects attracted to colours, one of which is by using colourful paper layered with adhesive. The use of coloured paper traps is one way to monitor the insects in the field. Therefore, identification can easilybe performed.Colours used can be in the form of the reflection of the light as well as other attractants and colours (Sihombing*et al*., 2013).

Insects as pests in plants have to be controlled in order to avoid damage which will result in reduced productivity (Abdullah andRauf, 2011). A number of measures have been taken to cut down the level of damage to plants caused by insects such as mechanical and physical control, farming, as well as using biological agents (Debeach, 1979). The physical control consists of use of traps, either physical trap or hormonal trap as attractants (Braham, 2014). One of the alternative control measures tried out in this research was the use of coloured paper and lights as mechanical traps.

The use of mechanical traps made of paper will help farmers minimizethe number of pests in vegetable crop. Based on the result of the research byThamrinandAsikin (2003), using yellow plastic can effectively attract 24 leaf-boring flies per week on average. Coloured traps can be used in combination with sex pheromones to trap the yellow stem-boring pest*Triporizaincertulas*in rice crop (HendarsihandUsyati, 1999).

This research will formulate an alternative pest control model by using coloured paper and lights to attract insects infecting vegetables.This research intends to put into practice the use of coloured trapping devices made of paper and lightsas one of the options in vegetable insect pest control.

II. MATERIAL AND METHODS

Coloured paper traps

The paper traps used in this research are ofred, yellow, and green colours which have been added ahesive on the surface for daylight observation. This is in accordance with the results of a number of research conducted previouslyon the use of attractants on paper to attract insects (Marikun*et al*., 2014), the use of coloured nets to prevent pest infestation in chilli(Utami*et al*., 2014), the use of sticky coloured traps and spice aroma to control warehouse pest(Rahayu*et al*., 2013), and the use of sticky coloured traps to monitor and evaluate the tobacco pest population (Sihombing*et al*., 2013).

Coloured light traps

In order to observe the insects at night time, light traps of red, yellow, and green colours which were coated with glue on the surface were used. These types of traps will be beneficial to farmers in capturing and recording the pests for the purpose of further agricultural studies (Thangalakshmi and Ramanujan, 2015). The use of light traps has been considered a classical insect pest control(Reddy and Ammika, 2015). Insect control using light traps is the oldest method (Augul*et al*., 2015). The use of solar power-based traps will effectively attract vegetable insect pests (SermsriandChonmapat, 2015).

Observation variables

The observation object of this research was the number of insect population trapped in the coloured paper and coloured lights. Next, all trapped population underwent an identification to determine the order, family, andspecies (Borror, 1987).

Research Method

This research utilized Randomized Complete Block Design (RCBD) consisting of 3 treatments and 4 replicates (Gomez and Gomez, 1995). Each treatment consisted of 3 types of coloured paper, namely red paper (R), yellow paper (Y), and green paper(G)as well asred light, yellow light, and green light. For each treatment, 4 replicates were performed.

This research was conducted in the experiment garden of SekolahMenengahKejuruanPembangunan Pertanian (SMKPP) Saree, LembahSeulawah Sub-district, Aceh Besar District, Aceh Province from JulytoAugust 2016. The data were analysed using analysis of variance (Anova) by comparing $\mathbf{F}_{value}$to$\mathbf{F}_{table}$on the scale of 0.05 %. If the difference between the two is very significant, a further test of Least Significant Difference (LSD) should be carried out at the level of α = 0.05%

III. RESULTS

The observation of the number and types of insects trapped in coloured paper indicated that the highest insect population was found in the yellow paper treatment(23.25),followed by green paper (7.50), and red paper(6.00) (Table 1). The result of the analysis of varianceshowed that the yellow paper treatment differed significantly from the yellow light treatment atthe level ofα 0.05% of the result of LSD test.The field observation was conducted from July to August 2016 (Figure 1; Figure 2; Table 2; Table 4).

Table 1. Average number of insects trapped in coloured paper

Treatment (colours of paper)	Replicate (r)				Number	Average
	I	II	III	IV		
Red paper (R)	6	6	4	8	24	6.00
Yellow paper (Y)	18	20	30	25	93	23.25
Green paper (G)	8	7	9	6	30	7.50
Total	32	33	43	39	147	36.75

Field observation data July-August 2016

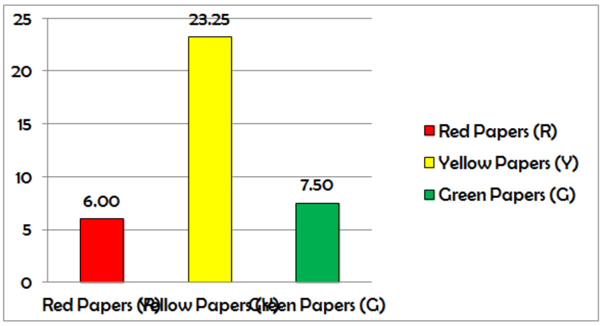

Figure 1. Insect population trapped in red, yellow, and green paper traps.

Based on the LSD test, the yellow paper treatment (Y) differed greatly from the red paper (R) and green paper treatment (G) at the level of 0.05 % in LSD test as shown in Table 2:

Table 2. The result of LSDtest for α=0.05in coloured paper treatment

Treatment	Treatment Average	+LSD	Notation
Red paper (R)	6.00	11.33	a
Yellow paper (Y)	23.25	28.58	b
Green paper (G)	7.50	12.83	a

Note: The numbers followed by the same letter in the same columnare not significantly different at the level of 0.05 % LSD test.

Based on the result of the coloured paper treatment observation, the highest insect population was found on yellow paper treatment (23.25), followed by green paper treatment (7.50), and red paper treatment (6.00) (Table 2).

Table3. Average number of insects trapped in coloured lights

Treatment (colours of paper)	Replicate (R)				Number	Average
	I	II	III	IV		
Red (R)	21	20	19	17	77	19.25
Yellow (Y)	32	29	27	25	113	28.25
Green (G)	10	9	11	8	38	9.50
Total	63	58	57	50	228	56.75

Field observation data July-August 2016

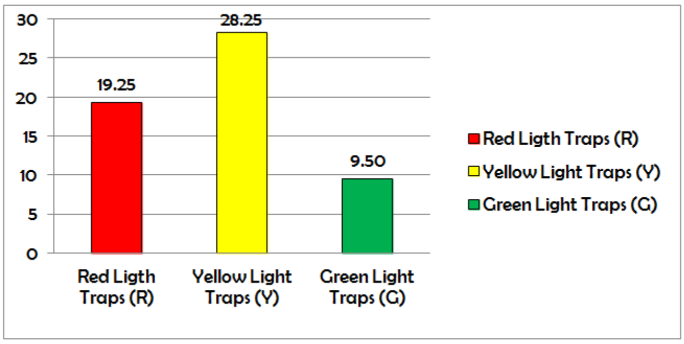

Figure2. Insect population trapped in red, yellow, and green light traps.

Based on the LSD test, the yellow light treatment (Y) differed markedly from the red light treatment (R) and the green light treatment (G) at the level of 0.05 % of LSD test, as shown on Table 4 below:

Table 4. Results of LSDTest for α=0.05in coloured light trap treatment

Treatment	Treatment Average	+LSD	Notation
Red light trap (R)	19.25	22.64	b
Yellow light trap (Y)	28.25	31.64	c
Green light trap (G)	9.50	12.89	a

Note: The numbers followed by the same letter in the same column are not significantly different at the level of 0.05% LSD test.

Based on the result of the coloured light treatment observation, the highest insect population was found on yellow light treatment (28.25), followed by red light treatment (19.25), and green light treatment (9.50) (Table 4).

IV. DISCUSSION

The identification of the insects found on the coloured paper treatment resulted in the following species:

Table 5. Speciesof insects trapped in coloured paper traps in corn plant ecosystem from July to August 2016.

No	Orderorder	Family	Species	Coloured paper traps		
				Red	Yellow	Green
1	Lepidoptera	Noctuidae	Ostrisniafurnacalis	4	14	3
2	Lepidoptera	Noctuidae	HelicoverpaarmigeraHubner	5	15	5
3	Lepidoptera	Noctuidae	Spodopteralitura	4	23	5
4	Diptera	Muscidae	Atherigonareversura	6	21	9
5	Homoptera	Delphacidae	Peregrimusmaidis	5	20	8
Total population				24	93	30

Source: Field observation data July-August 2016.

Colours are attractive to insects because of their all-directional reflection. A large number of phytophagous insects respond positively to the light reflection pattern from host plants and the response can be very specific. Very often, substrates with a maximum reflectance of 500-580 *nm*produce the largest outcomee.g.response. But in some cases, the response may be associated with the specific stages of the host plants(flowering or fruiting stage) with a maximum reflectance on the other side of the spectrum (Prokopy and Owens,1983in Blackmer*et al*., 2008).

Braham (2014)mentioned the roleof trap colours in attractingmale *T.absoluta*. We hypothesise that the effectiveness of using colours in insect traps will increase when pheromones are given as feedback. RoubosandLiburd(2008) *in* Braham (2014)reported significant differencesbetween theeffects of using colours in traps and that of using synthetic sex pheromones on capturing male grape root-boring insects*Vitaceapolistiformis* (Harris) (*Lepidoptera:Sesiidae*). Yellow and green traps were effective in capturing the insects.There was no difference between male and female insects in choosing the colours of the traps.

*Ostriniafurnacalis*Guenee (*Lepidoptera: Crambidae*) is a corn stem-borer widely spread out in Asian regions. Its damaging capacity reaches up to 98% (Abdullah andRauf, 2011). According to Lopez *et al*., (2014),*O. furnacalis*likes corn in the flowering phase in which female insects lay the eggs in corn silk.

The species of *Helicoverpaarmigera*Hubner,1809 (*Lepidoptera: Noctuidae*) are also widely distributed around the world such as *H.armigera*Hubner*, H. obsolete Fabricius, H. conferta, H. fusca Hardwick, and H. uniformis.*Delattreand King (1994) elaborated that this insect has translucent eggs placed in groups, green colouredlarvae, brown pupa placed underground, active stage in rainy season, and corn as host plants. According toTuliabu*et al*., (2015), corn cob-boring pest *Helicoverpaarmigera* Hubner *(Lepidoptera : Noctuidae)* are widely scattered (25%) in Bone District, Gorontalo Province.

Spodopteralitura Fab. (*Lepidoptera : Noctuidae*) is a polyphagous pest striking many types of plants such as corn, soy, cotton, and tomato. It has reportedly150 species spread out around the world (Kranthi*et al*., 2012). According to Singh *et al*., (2015), *S. litura* Fab.infects peanut, corn,ornamental plant, and mustard.

Bactroceradorsalis (*Diptera:Tephritidae*) attacking plants are*B. dorsalis, B. umbrosus, B. albistrigatus, B. cucurbitae* (Marikun *et al*., 2014). Sunarno and Stefen (2013) listed*Bactrocera. B. carambolae, B. Musae, B. cucurbitae, B. curifera,* and *B.dorsalis.* The primary plants of *Bactrocera*spp*a*mong others are pomegranate, mango, orange, papaya, and tomato (Kuyama, 1989). According to Weems *et al*., (2015) *Bactroceradorsalis*is native to Asia and attacks fruit plants.

Atherigonareversura (*Diptera:Muscidae*) is aplanthopperin corn and other gramineae plants as identified by Ribeirio *et. al*. (2016), which consists of *Atherigonanigritibiella* Fan & Liu, 1982., *A. orientalis*Schiner, 1868., *A. oryzae*Malloch, 1925., *A. reversura* Villeneuve, 1936., *A. seticauda*Malloch, 1926., and *A.theodori* Henning, 1826.*Atherigonaspp*attacks plants in their generative phase which can decrease the production up to 80%. The attack starts when the plants are 2-5 days old which leads to their termination(Pabbage*et al*., 2015).

*Peregrinusmaidis (Homoptera: Delphacidae)*is aplanthopper targeting corn plants. In addition, according to Alviar *et al*., (2015),*P. maidis* is a vector for Maize Mosaic Virus (MMV) which is an important pathogen of corn plants. The potential transmission of MMV by *P. maidis* starts in the larval stage up to the adult stage.

Table 6. Insect speciestrapped in coloured light traps in corn plant ecosystemfrom July to August 2016.

No	*Order*	*Family*	*Species*	Coloured Light Traps		
				Red	Yellow	Green
1	*Coleoptera*	*Curculionidae*	*Cylasformicarius*	4	7	3
2	*Coleoptera*	*Coccinelidae*	*Monochilussexmaculatus*	5	8	2
3	*Diptera*	*Agromizidae*	*Ophimiaphaceoli*	7	10	3
4	*Diptera*	*Muscidae*	*Atherigonareversura*	6	9	4
5	*Diptera*	*Tephritidae*	*Bactroceradorsalis*	4	11	3
6	*Hemiptera*	*Alydidae*	*Leptocorizaacuta*	5	7	3
7	*Hemiptera*	*Miridae*	*Nezaraviridula*	7	9	3
8	*Homoptera*	*Delphacidae*	*Peregrimusmaidis*	8	9	4
9	*Homoptera*	*Aphididae*	*Aphis maidis*	3	7	2
10	*Orthroptera*	*Acrididae*	*Valanganigricornis*	7	8	3
11	*Orthroptera*	*Acrididae*	*Locustamigratoria*	5	9	1
12	*Orthroptera*	*Gryllidae*	*Gryllusmitratus*	6	7	2
13	*Orthroptera*	*Gryllotalpidae*	*Gryllotalphaafricana*	3	4	1
14	*Hymenoptera*	*Pamphilionidae*	*Paphiliumparsicum*	7	8	4
Total population				77	113	38

Source: Field observation data July-August 2016.

From the observation of the coloured lights in the experiment garden, it was discovered that there were also a number of non-target insects in corn plants. This is due to the presence of mixed vegetation other than corn such assweet potato, peanut, eggplant, chilli, and fruit.

The insect *Cylasformicarius* (*Coleoptera: Curculionidae*) attacks potato, jicama, cassava, and sweet potato tubers. The life cycle of C. formicariusis 35-40 days. There are3 larval instars each of which lasts for 21-35 days. The egg phase is between 7 to 10 days (Nonci, 2005). This insect has been reported (Kalshoven, 1981) as the main pest of sweet potato in storage (up to30%) (Mauludiana*et al*., 2015). Mansaray*et. al*., (2015) listed *Cylaspuncticollis* as another species of *Cylasspp*infecting potato.

The beetle *Cocinellidae*of the order Coleoptera is the insect found in food crop such as vegetables and fruit. This *Cocinelid* beetle which is commonly known as 'helmet beetle' because of its helmet-like shape is present both as predator and pest. *Coccinelidae*mostly preys on aphis in plants. According to Wagiman (1987), one of the helmet beetle species *Menochilus sexmaculatus* effectively controls black flea in corn or string bean plants.

The insect *Ophimiaphaseoli (Diptera : Agromizidae)*or more commonly known as 'seed fly'. This insect infects plants during the cotyledon formation phase. Jorani *et al*., (2016) stated that *Liriomyzatrifolii* (Burgess, 1880) which is also from the order *Diptera* and family*Agromizidae*is a globally distributed phytophagus insect and reportedly has 2,500 identified species, a wing span of 1 mm, maximum size of 6.5 mm, egg laying period of 2-5 days if the temperature is appropriate, larval period of 4-7 days, and life cycle of 18-24 days at 24 ^{o}C.

Another speciesof this seed fly is *Atherigona sp*. According to Pabbage*et al*., (2015), this pest lays egg one by one underneath the surface of the leaves at night time. There are three larval instars with the overall length of larval stadium of 6-18 days. The resting during the pupa stage takes place in the base of the stem underground for 5-12 days. The size of imago is 2.5-4.5 mm. The female imago lays up to 70 eggs 3-5 days after mating. The life cycle is 21-28 days.

There are reportedly 50 species of *Bactroceradorsalis (Diptera: Tephritidae)*spread out across the Asian regions. *B. dorsalis*is mostly found in Sri Lanka, India, Indonesia, and the Philippines (Drew and Hancock, 1994). The hostplants are mango (*Magniferaindica*), papaya (*Carica papaya*), and banana (*Musa paradisiaca*). Drew and Hancock (1994) added that the female insect places the eggs on the fruit peel which will hatch in 1-3 days. The active eating stage of the larvae is 9-35 days and its growth can take placeat 13 ^{o}C. The pupal stage lasts for 1-2 weeks.*B. dorsalis*can survive at 7 ^{o}C but will die at 2 ^{o}C.

According to Weems *et al*., (2015), *B. dorsalis*is spread outacross Asia inBangladesh, China, Hong Kong, India, Indonesia, Myanmar, Nepal, Taiwan, and Vietnam. An adult insect is 8.0 mm in length, has a wing span of 7.3 mm and various body colours. Those found in Indonesia have a yellow body and a two-joint-size protruding abdomen. The eggs are transparent measuring1.17 x 0.21 mm. The maggot type is just like other flies' larvae in general. *B. dorsalis*attacks fruit and vegetable plants (Anonimus, 2014). In addition to being a pest, *B. dorsalis*is a vector for *Escherichia coli*which causes digestive diseases to humans (SunarnoandStefen, 2013).

Leptocorizaacuta, L. oratorius, L. varicornis, and *L. chinensis*are the species of *LeptocorizaacutaThunb. (Hemiptera:Alydidae)*, the primary cause of rice crop damage in Asia(Jahn*et al*., 2004). Some of them can survive in the grass as their temporary shelter until the rice is grown.Dutta and Roy (2016) stated that the damage caused by *L. acuta*reaches 10-20% of the total cultivated plants. They also added that the life cycle of*L. Acuta*begins from eggs, followed by larvalinstars 1-6, and eventually adult insect which can survive on plants other than the primary ones.

*Nezaraviridula (Hemiptera: Miridae)*is a cosmopolitan sap-sucking insect attacking legumes. Due to its aggressive nature it can attack all plants; therefore, this pest is also found in corn. It belongs in the Phylum Arthropoda, class Insecta, order Heteroptera, family Pentatomidae, genus Nezaraviridula Linneus 1758, and is commonly called green stink bug (Grozea, 2012). Further more, an adult green stink bug is morphologically greenin colour, has brown legs and triangle-shaped scutellum typical of Hemiptera, and its larvae's abdomen is brown with white spots.

According to Dyer *et al*.,(2014), this insect is predominantly present in the regions of Asia, Africa, Europe, and Middle East. It lays its white eggs in groups of 30-130 and its life cycle is 65-70 days. The eggs will hatch after 5 hours. This type of insects can cause damage to a wide range of fruit and vegetable plants.

Peregrinusmaidis (Homoptera:Delphacidae) is not only a pest in vegetable plants but also a vector for a virus. Corn stalk-sucking *P. maidis* (Ashmead) is a vector for *Maize Mosaic Rhabdovirus* (*MMV*), an important disease infecting corn and sorghum plants (Alviar*et al*., 2016). Virus vectors in crops *P. maidis* and *Dalbulusmaidis*can be controlled using entomopathogenic fungi such asBeuveriabassiana, *Matharhizium anisopliae*, *Bacillus amyloliquefacien*, *B. pumilus,* and *B. subtilis* (Toledo *et al*., 2015).

Aphis maidis (Hemiptera: Aphidae), also known as *Aphis glycines*(Matsumura) (*Hemiptera: Aphididae*),is a pod-boring insect in soybean, *cucurbitae, graminae,* corn, rice, and sorghum (Behrens *et al*., 2015). Control can be carried out by using sticky light and paper trapping devices. Rebenatto et al., (2015) asserted that the cereal plant pest *Aphids* (*Hemiptera: Aphididae*) is the most potential pest in crops. In addition to being a pest, aphids can also function as a vector for cereal yellow virus (CYDVs) and yellow dwarf disease (YDD) (Parizoto*et al*., 2013).

Locustamigratoria (Orthroptera: Acrididae) grasshopper is a grassland tropical insect widely spread in Asia (Indonesia, China, Bangladesh) which can causedamage of up to 20,000,000 hectares of grassland(Sun *et al*., 2015). Sun *et al*., (2015) added the types of grasshoppers largelyfound in vegetation and grassland such as those from the *family Acididae, sub family Acridinae, species Acridacinerea (Thunberg), Acridaoxycephala (Pallas), subfamily Catantopinae, species Dericorysannulataroseipennis (Redt.), Calliptamus barbarous cephalotes Costa,family Tetrigidae, subfamily Tetriginae, speciesTetrix japonica* (Bol.), and *Tetrixtartara* (Bol.). Arya *et al.*, (2015) stated that the Himalayan region houses an abundance of species belonging to the order*Orthroptera*such as*family Acrididae*: species*Oedipoda Himalayan* (Uvarov), *Xenocatantopskarnyi* (Kibry), *Aulacobothruslueips* (Walk), *Gastrimargus transverses* (Thun), and*family Tettigonidae*: *Mecapodasp, Elimaeasp, Himertulakinneari*(Uvarov).

The female grasshopper *Locustamigratoria* can lay up to 270 eggs which will hatch after 17 days. The nimpha undergoes 5 instars prior to transforming into an adult insect. The nimpha stadium lasts for 38 days and the life cycle 76 days. The insect can produce 4-5 generations in a year (Pabbage*et al*., 2015). Based on the research bySiregar*et al*., (2014),the diversity index value of insects in corn plants with H' value is 2.368 and with moderate diversity value.

Species *Valanganigricornis* (*Orthroptera: Acrididae*) also predominates the corn plant ecosystem in the observed area. The types found, among others, were*Phlaeobaantennata* (Brunner) and *Phlaeobainfumata* (Brunner). According to Tan and Kamaruddin (2014), insects of the order *Orthroptera* are widespread throughout Asia and predominating grassland, farmland and wilderness habitats. Several families which can exist in various ecosystems are *Tetrigidae, Acrididae, Ensifera, Tettigonidae, and Gryllidae*.

The other two species identified in the observation were *Gryllusmitratus (Orthroptera: Gryllidae)* and *Gryllotalphaaficana (Orthroptera: Gryllotalpidae)*. A research by Gupta (2016) identified the following insects from the family Gryllidae, subfamily Gryllinae, genus Modicoggryllus (Chopard-1961), M. confirmatus (Walker-1859), family Tettigonidae, subfamily Conocephalinae, genus Conocephalus (Thunberg-1815), Anisoptera (Letreille-1829), Conocephalus maculatus, Hexacentrusinicolor (Serville-1831).Furthermore, Gupta (2016) listed *family Acrididae, subfamily Acridinae, genus Acrida* (Linneus-1758), *Acridaexaltata* (Walker-1859), *Truxalisexaltata* (Walker-1859), *Acridagigata, Acridaturita, Phlaeobainfumata* (Brunner-1893), *Phlaeobapantili* (Bolivar-1902), *Calliptamuspanteli* (Bolivar-1902), *Calliptamus barbarous barbarous* (Costa-1836).

Paphiliumpersicum (*Hymenoptera: Pampilionidae*) is a type of insect pest predators found in the paper and light traps. *P. percicum*effectively controls aphis maidisinfecting corn plants. It is also known as spider wasp from the order*Hymenoptera*, family *Pompilidae.* Pitts and Joseph (2007) reported that there are 6 species found in Fiji, namely *Anopliuscaerulescence* (DallaTorro), *Dendropompilusvatiensis* (Williams), *Anopliuselatus* (Smith), *Anopliusvitiensis* (Williams), *Cyphononyxvitiensis* (Turner), and *Heterodontonyxguerini*. According to Russell (2014), almost 5000 species of Colombian spider waspshave been recorded such as*familyPompilidae, subfamily Pepsinae, genus Ageniella, species accepta* (Cresson), *blaisdelli* (Fox), *coronate* (Banks), *euphorbiae* (Viereck), *gresea* (Townes),genus *Alloporus*, species *pulchellus*(Banks),genus *Auplopus*, species *Auplopusarchitectus* (Say), *A. caerulescens* (Walsh), *A. nigrellus* (Banks), genus *Cadiadurgus*, species *C. hyalinatus* (Fabricius).

V. CONCLUSIONS

Highly influential paper usage and light yellow, green, and red against the presence of insects in maize. yellow highly favored insects. color paper suitable for insect monitoring Diurnal, for insect monitoring Nocturnal suitable light traps.

ACKNOWLEDGMENTS

The writers would like to thank the research and community service centre, SerambiMekkah University Banda Aceh,and the researcher team for the support and encouragement throughout this research.

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