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Effects of insect trap type and pheromone type on insect pest attraction in blueberries production.

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DEDICATION

To my parents with love, Mr and Mrs Sithole l love you yesterday and forever.

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ABSTRACT

Trap type and pheromone type are frequently used to attract and kill most common insect pests in blueberry fields. This study was conducted to determine the effectiveness of trap type and pheromone type on the attraction of common insect pest in blueberry fields. Performance and efficacy of trap type (sticky rolls, blue and yellow) and two pheromone types were evaluated at Palmlife Ivanhoe farm located at Juru growth point, Goromonzi in Mashonaland East. Trap type consists of bright colors of blue and yellow sticky roll which attract the insect moth and pheromone type consists of mego and ABW trap. The experiment was laid down in an RCBD design arranged in a factorial manner. Two experiments were done independently to observe the effect of trap type and season change on number of insect pest caught and also the effect of pheromone type and season change on the number of insect pest caught. Another objective of effect of season change on the insect attraction was observed on both trap type and pheromone type. The results showed that trap type and season change interacted on number of insect pest attraction which are Sting bug, African Bollworm, Tip Wilter, Cutworm, Fruit flies and Capsid ($p<0.005$). The results also showed that there is an interaction between pheromone type and season change on number of insect pest attraction which are Sting Bug, African Bollworm, Tip Wilter, Cutworm, Fruit flies and Capsid ($p<0.005$). The overall experiment showed that highest mean number of catches of different insect pest was in trap type in all different seasons which are Summer, Autumn, Winter and Spring and lowest average number of catches was in pheromone type throughout the four different seasons.

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Chapter 1

1.1 Background:

Blueberries are flowering plants with a color that ranges from indigo to deep purple when ripe and they are juicy sweet in taste. (Bonsu, 2018).The scientific name is *Vaccinium sect cyanococus* of family *ericaceae.* Blueberries are attacked by different direct pests which include rose beetle *(adoretus sinicus),* fruit flies *(drosophila melanogaster),* tip wilter (*Bradysia),* stink bugs (*Halyomorpha halys Stål),* bollworms*(Pectinophora gossypiella)* capsid*(Bryocoropsis laticollis)* , fungus gnat(*Bradysia)* and so many others. A direct pest is one that feeds on flowers, buds, and or fruit and can potentially reduce blueberry yield. Direct pests can cause severe losses if unmanaged. (De Fransesco, 2005).Many trap type and pheromone type attract insects and can be used to monitor or directly reduce insect populations. The effective use of attractants and traps requires knowledge of basic biological principles and the pest or crop specific details involved in individual applications. Trap type use light, bright colors and shapes to attract pest and pheromone type might attract a particular type of sex or insect. (Purcell et al., 2012).

According to (Ekesi and Billah 2006), traps and pheromones are used to monitor and detect insect activity in various areas, particularly hectare-sized blocks where blueberries are grown. There are devices called "bait stations" that combine an attractant, a killing agent, and a device that holds both of them.

1.2 Problem Statement:

Insect pest infestation can result in the damage of the blueberry fruit and plant (leaves, stems, flowers and roots). We do not know the effect of pheromone type and trap type interaction on attraction efficiency. The problem statement is to find out effect of pheromone type and trap type interaction on insect attraction efficiency.

1.3 Justification

The trap type and pheromone types can be observed during the project to see which one is more effective than the other in different seasons.

1.4 Objectives

1.4.1 Main objective:

To determine the effect of trap type and pheromone type on insect attraction efficiency.

1.4.2 Specific objectives:

To assess the effect of trap type and pheromone type on number of insects trapped in blueberry fields.

To assess effect of trap type and pheromone type on the spectrum of pests attracted.

To determine effect of season change on spectrum of pests trapped in a blueberry field.

1.5 Hypothesis

Ho Trap type and pheromone type have effect on number of insects trapped in pest monitoring.

Ho Season change have effect on spectrum of pests trapped in a blueberry field.

Ho trap type and pheromone type have effect on the spectrum of pests attracted

Chapter 2

2.0 Literature review

Blueberry plants are perennial woody shrubs that mature in five to seven years (Bushway, 2015). When they are ripe they are easy to twist and turn during reaping and they turn dark blue in colour. Insect traps are used to monitor or directly reduce populations of insects or other arthropods, by trapping individuals and killing them (Purcell, 1998). They typically use food, visual lures, chemical attractants and pheromones as bait and are installed so that they do not injure other animals or humans or result in residues in foods or feeds. Visual lures use light, bright colours and shapes to attract pests (Mankin *et al.*, 2010). The trap types vary and they consist of the light traps, adhesive traps and flying insect traps. Based on how the insects being targeted behave, different designs are applied. It is frequently done to survey nocturnal moths using light traps. Grasshoppers and some beetles are drawn to distant lights. In order to draw insect pests attracted to bright colours, sticky rolls with bright colours like yellow and sky blue are placed around the fence at the boundaries of the farm. The intent of flying insect traps is to capture flying or windblown insects (Purcell, 1998).

Insects and other animals communicate with one another using chemicals called pheromones. These chemical signals are used by insects to find food, warn other insects of predators, or attract mates. Traps can be used to track target pests in residential or agricultural settings using particular pheromones (Gilbert, 2007). Click beetle adult pheromone traps have also been used to determine what species may be local. This strategy has been more effective in Europe than in North America because there are lures for every known economic species in Europe. There are aggregation pheromones and sex pheromones. Aggregation pheromones are produced by male and attract males, females, adults and larvae of same species. It acts over short distances. Sex pheromones are produced by females and attract adult males of same species. It acts over long distances.

A fruit tree branch is tied with a string to hold traps that contain an attractant and a killing agent. Typically, they are positioned 2 metres above ground on the western side of fruit trees (De Meyer et al., 2015). To count and record the number of specimens caught, they are routinely emptied.

2.0.1 Trap all Mego

Trap all mego can be used to control and or monitor male fruit fly from the *Bactocera* and *Ceratitus genus*. The mego pherolure need to be stored in the bucket. When the clear vial and yellow block are placed in the bucket they will need to be replaced every 16 weeks. Place clear pipes inwardly and clip in place. Attach lid firmly, this can be a rotational clip. The black hooks attach to the lids and can assist with hanging the trap. Preferably position the trap as high up as possible as the pheromone dissipates downwards. *(*Berryworld SA, n.d)

2.0.2 ABW trap

These traps are hooked on a stand and the containers contain a diclofose and a tv pherolure. The pherolure has strong scent that attracts insects and once they get trapped inside the ABW container, the diclofose kills the insect (BerryWorld SA, n.d).

2.1 Economic importance

A kilogramme of blueberries, a cash crop with a high demand market in Europe, can be purchased for $17.10. The country's blueberry exports have increased by 16 times in less than a decade, from 12,951 metric tonnes (MT) at the end of the 2015–16 campaign to an estimated

219,982MT exported in the most recent 2021–22, according to the 2022 State of the Institutional Buyout Industry Report. Zimbabwe now exports more blueberries than any other country in Southern Africa, bringing in $60 million in US dollars in 2022 (Bhasera, 2022). Planting the crop costs about $100,000 per hectare, and it will produce that much foreign currency in the future (Bonsu, 2018). Blueberries for export should be of excellent quality, free of flaws, and packaged in accordance with market demand. Pitting, dry scars, wet scars, calyx browning, poor bloom, bladdery, shrivel, progressive mould, immature green, immature red, white backs, stems, beard, and bleeding are just a few of the defects that can occur with blueberries (BerryWorld SA, n.d.).Berries lead to employment opportunities for local people and thereby improving the living standards of employees. The land is utilised well which brings many environmental benefits.

2.2 Nutritional importance

According to (Longstroth, 2017), blueberries are a "natural health-package," containing a variety of classes of bioactive compounds that support a number of established health benefits. Due to their wide range of polyphenolic compounds, which has been scientifically reported to have a high antioxidant capacity, these tasty berries have drawn a lot of attention and exceptional interest from scientists, nutritionists, food manufacturers, and, of course, consumers (Lespinasse et al., 2018). According to (Studl et al., 2015), blueberries have positive effects on a number of chronic diseases, including diabetes, cancer, cardiovascular disease, and neurodegenerative disorders. . The high concentration of antioxidants in these berry fruits is responsible for these health benefits. There has been research on the antioxidant potential and phenolic content of various blueberry cultivars, but more work needs to be done to accurately assess the chemical makeup of blueberries, which includes vitamins, minerals, and amino acids (although they are only present in trace amounts) (Gough et al., 2013). In addition to being available in preserved forms like canned, frozen, and dried, blueberries, like other berries, are a common ingredient in a number of foods and beverages that have undergone thermal processing (such as jams, jellies, and juices). The consumption of blueberries keeps the skin smooth and youthful.

2.3 Major pest that affect blueberries

Blueberries are attacked directly by a variety of pests, such as the rose beetle (*adoretus sinicus)*, fruit flies *(drosophila melanogaster*), tip wilter (*Bradysia*), stink bugs (*Halyomorpha halys Stl*), bollworms (*Pectinophora gossypiella*), capsid (*Bryocoropsis laticollis*), and cutworm (*Agrotis ipsilon*). If a pest feeds on the blooms, buds, or fruit of a plant and has the potential to affect blueberry yield, it is considered a direct pest *(*DeFrancesco, 2005).

2.3.1 Beetles in blueberries.

Since they can eat the entire rose flower, including the flower, foliage, and buds, beetles are among the most troublesome pests that affect roses. Rose flowers, leaves, and even their roots are all eaten by beetles (Fulcher, 2006). Some kinds of beetles only consume these specific parts of the rose, while others consume the entire flower. Roots from rose flowers are frequently consumed by beetle larvae. While older larvae have been observed eating whole rose roots, younger larvae have been observed eating root hairs. Insects that can feed on the entire rose flower, including the flower, foliage, and buds, include beetles, which are among the most troublesome pests of roses. According to (Fulcher, 2006) beetles eat the roses' flowers, leaves, and even roots. All of the rose's parts are consumed by some types of beetles, but not all of these particular parts. The roots of rose flowers are frequently eaten by larval beetles. In contrast to older larvae, which have been observed eating whole rose roots, younger larvae have been observed eating root hairs (Fulcher, 2006).

2.3.2 Tip wilter in blueberries.

The tip wilter creates fluid-like chemical substances that wilt the tips of the shoots and inhibit growth. Drying of terminal leaves and tip wilting in blueberries are caused by the Blueberry Tip Borer (*Hendecaneura shawiana*) (Russell, 2011).

2.3.3 African Bollworm in blueberries

A moth larva known as a "African Bollworm" (*helicoverpa armigera*) attacks the fruiting bodies of some crops, including blueberries. *Helicoverpa armigera*, the African bollworm, damages the foliage and feeds on the young fruitlets, which causes bumps or raised corky growths to appear on the mature fruit. As more drupelets are consumed, berries start to disintegrate (Curry et al., 2014). On blueberries, the larvae consume both the leaves and the fruit, leaving behind deep circular holes in both the immature and mature fruit, as shown in the illustration. Microorganism infestation may take place in the damaged area, which may result in severe rotting.

2.3.4 Fruit -fly damage in blueberries.

By piercing the fruit's skin to lay their eggs, fruit flies directly harm the fruit (Ekesi et al. 2007). Fly intestinal flora bacteria are transferred into the fruit during egg laying. The tissues encircling the egg rot due to these bacteria.

2.3.5 Cutworm in blueberries.

Spanworm and cutworm infestations on blueberry plants typically leave behind large, irregular holes in the flower buds. The majorities of these buds wilts and turn brown. Insects continue to feed as the buds enlarge and early spring bloom. (Liveau et al., 2016).

2.3.6 Capsid damage in blueberries

The sap-sucking capsid bug (*Bryocoropsis laticollis*) prefers to eat the new plant growth. Leaf tissues die as a result of the harm they inflict with their mouthparts. (BerryWorld SA,-undated).

CHAPTER 3

3.1 Study area

The experiment was carried out under field conditions at Palmlife in Goromonzi at Juru growth point. The farm is located in Mashonaland East at coordinates -17.67625, 31.43746. Mashonaland East soil pH is 4.0 to 4.4 which is strongly acidic on the Calcium Chloride scale. The soil type is dominantly clay soil. Mashonaland East is one of the coldest regions in Zimbabwe with an average daily high temperature of only 26 degrees Celsius. For several months of the year, it is warm to hot at temperatures continuously above 25 degrees, sometimes up to 30 degrees. Wind Gusts. 4 mph, humidity 94%; indoor humidity 78 %. (Chemistry and Soil Research Institute 2021).

3.2 Experimental design

The trial was laid down in an RCBD design arranged in a factorial manner. There were two factors; trap type and pheromone type. Therefore, two experiments were done separately whereby on one experiment it was to observe effect of trap type on number of insect pest attraction throughout the different four seasons and on another experiment it was to observe effect of pheromone type on number of insect pest attraction throughout the different four seasons which are Summer, Autumn, Winter and Spring. There was one trap type of two different colours which are blue and yellow sticky rolls. Pheromone type had two levels which are trap all mego and ABW traps. The traps are different models and contain different elements to attract and kill insects.

3.3 General Management of trial

I placed the sticky traps along the similar positions in the field in order to maintain uniformity and equal probabilities in the distribution of the traps. Each experiment was replicated three times. I did the same with the pheromone traps.

3.4 Data collection.

The traps were left for sixteen weeks in the field because the pherolure and sticky traps expires after sixteen weeks but number of different insect moth caught on sticky rolls and inside pheromone bucket traps was recorded twice a week during scouting. The insect pest were collected and counted in each trap as well as classifying the insects according to their names and time of the season. Some quantitative analysis of the data was done to test the hypotheses developed in chapter one. This was observed for all different seasons which are summer, autumn, winter and spring and average number of moth caught was recorded.

3.4.1 Placement of traps

I placed the traps (sticky rolls) and pheromone types in selected hectares of blueberry plantations. I placed the sticky rolls and pheromone types at 3 different stations on each hectare for each experiment. I did this to award every trap at the front, the middle and the end of the field. This was done to ensure that the traps stood an equal chance of catching insect pest

3.4.2 The traps

The traps used were ABW trap, Mego trap, and the sticky traps.

3.4.2.1 Sticky rods/traps

Fig 3.4.2.1 Sticky traps Source: Baines (2023))

The sticky traps are developed using sticky glue to attract pests. The sticky traps were blue and yellow strips which have a paste on them which attracts and kills insects. The figure above illustrates the sticky traps which were used in the experiment. The sticky traps are manufactured by Crop serve, a local Zimbabwean company.

3.4.2.2 ABW Trap

The ABW trap is shown in the figure below.

(Source: Crop serve (2023))

Fig 3.4.2.2 **ABW trap**

The traps used an attractant and poison combination to kill insect pests. The attractant was a pheromone which the manufacturer of the trap chose. The pheromones attract insects and the poison kills them within the trap. The ABW trap is a specific model developed by Insect Science, a South African company which deals in insecticides and pesticides. The ABW model is branded the Bucket Funnel Trap. The trap has within it some pheromones which attract insects and a poison which kills them as they get trapped inside.

Mego traps

(Source: Crop serve (2023))

Fig 3.4.2.3 **Mego trap**

The Mego trap, like the ABW also uses pheromones to lure pests and have within them a poison to kill the insects after they are lured. The Mego traps are manufactured and distributed by Crop serve, a local Zimbabwean company.

3.5 Data analysis

Data is going to be analysed using GenStat version 20. The LSD Fischer's test is going to be used to separate means.

Chapter 4

4.0 Trap type Results

4.1 The Effects of Trap Type on African Bollworm Moth in Different Seasons

There is an interaction between the trap type and the season change on number of insect pest attraction ($p<.001$). Blue color sticky roll in autumn gave the lowest African bollworm count and yellow sticky roll in winter gave the highest count.

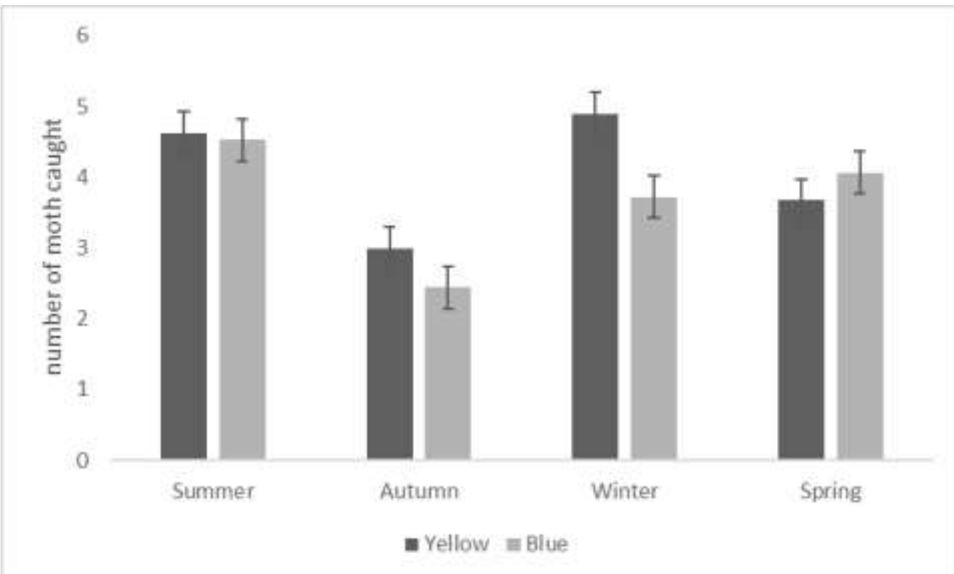

Figure 4.1 showing the effects of trap type on African Bollworm moth in 4 seasons.

4.2 The Effects of Trap Type on Tipwilter Moth in Different Seasons

There is an interaction between the trap type and the season change on number of insect pest attraction ($p<0.001$). Yellow sticky roll gave the lowest tip wilter count in winter and blue sticky roll gave the highest tip wilter count in summer.

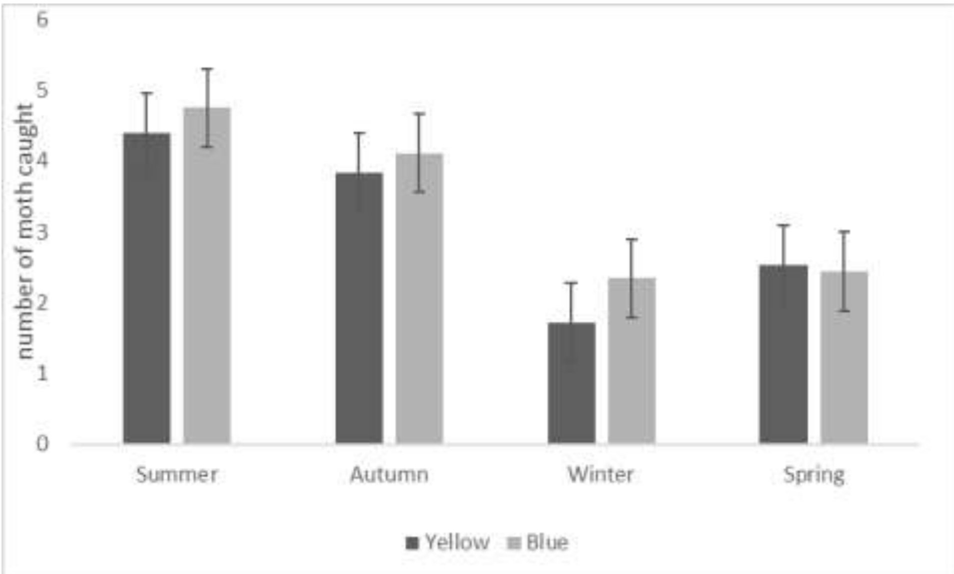

Figure 4.2 showing the effects of trap type on Tipwilter in 4 seasons.

4.3 The Effects of Trap Type on Sting Bugs Moth in Different Seasons

There is an interaction between the season change and the number of Sting bugs trapped ($p<.001$). The number of Sting bugs caught decreased in winter and increased in autumn. Sticky roll color had no significant effect on the number of Sting bugs caught by the traps (p0.448).

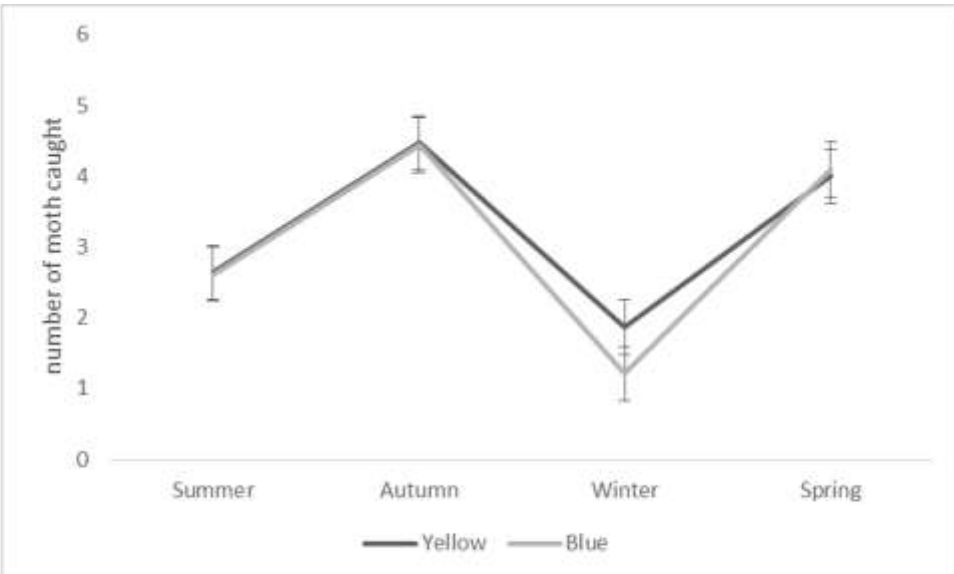

Figure 4.3 showing the effects of trap type on Sting bugs moth in 4 seasons.

4.4 The Effects of Trap Type on Capsid Moth in Different Seasons

There is an interaction between the season and the number of Capsid trapped (p=001). Yellow sticky roll in summer gave the lowest count of capsid and blue sticky roll gave the highest capsid count in winter.

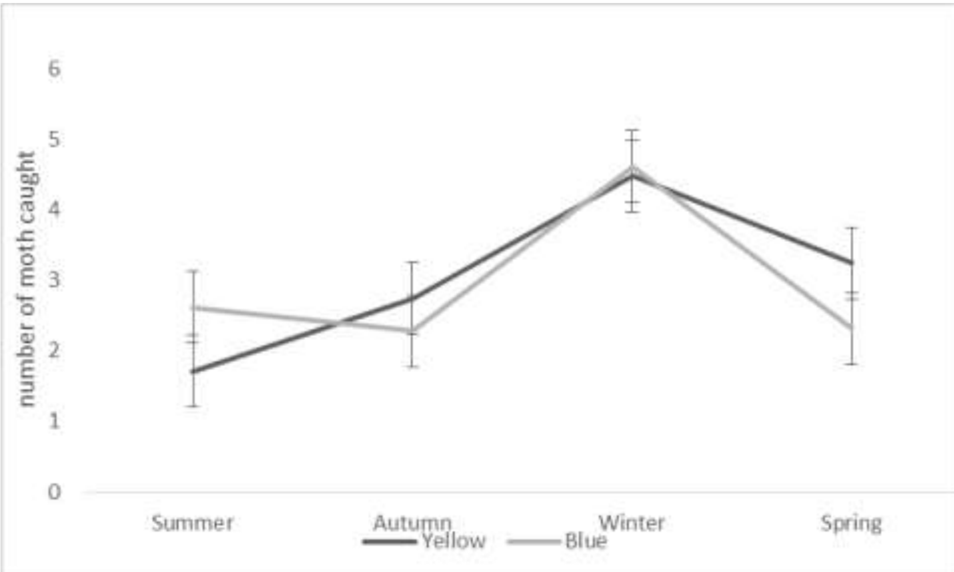

Figure 4.4 showing the effects of trap type on Capsid moth in 4 seasons.

4.5 The Effects of Trap Type on Cutworm Moth in Different Seasons

There is an interaction between the season and the number of Cutworm trapped (p=003). Yellow sticky roll gave the lowest cutworm count in winter and blue sticky roll gave the highest cutworm count in summer.

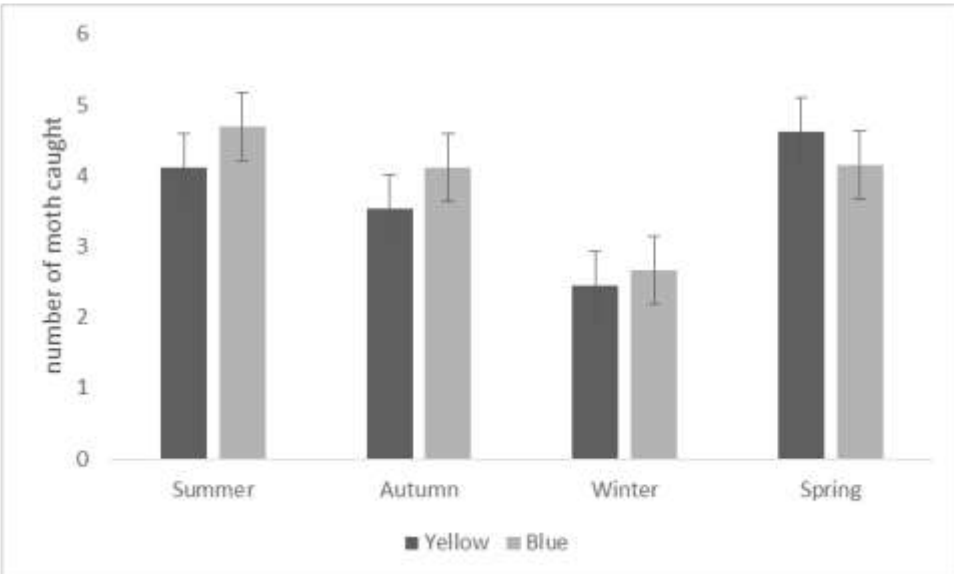

Figure 4.5 showing the effects of trap type on cutworm moth in seasons.

4.1 Pheromone Type

4.6 The effects of pheromone type on African Bollworm moth in different seasons

There is an interaction between the season change, pheromone type and the number of African Bollworms trapped (p=002, p<.001) respectively. Mego had the lowest bollworm counts in summer, autumn and winter. ABW traps had the highest bollworm count in spring.

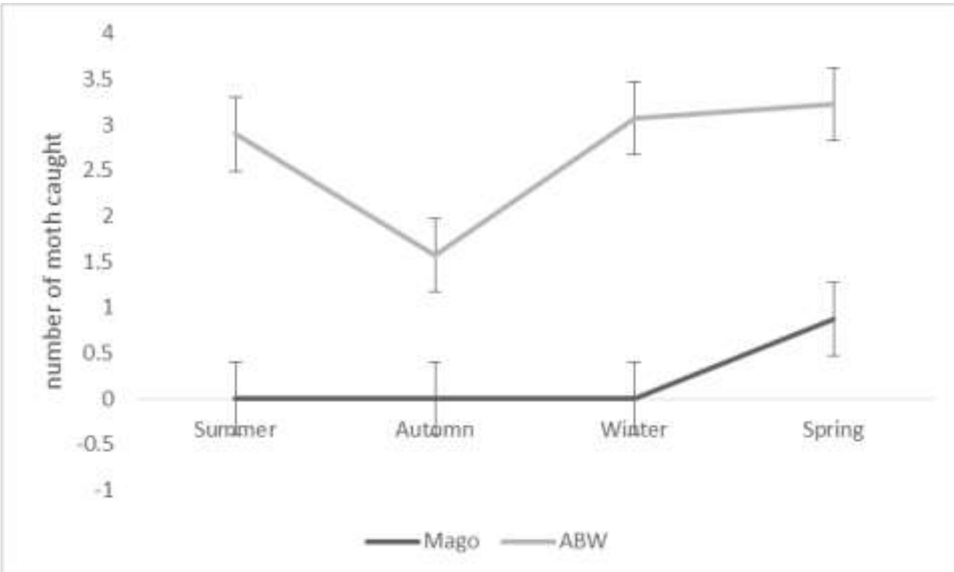

Figure 4.6 showing the effects of pheromone type on African Bollworm moth in 4 seasons.

4.7 The Effects of Pheromone Type on Tipwilter Moth in Different Seasons

There is an interaction between the season change, pheromone type and the number of Tip wilter trapped (P<001). Mego had the lowest tip wilter count in summer, winter and spring. ABW gave the highest tip wilter count in summer.

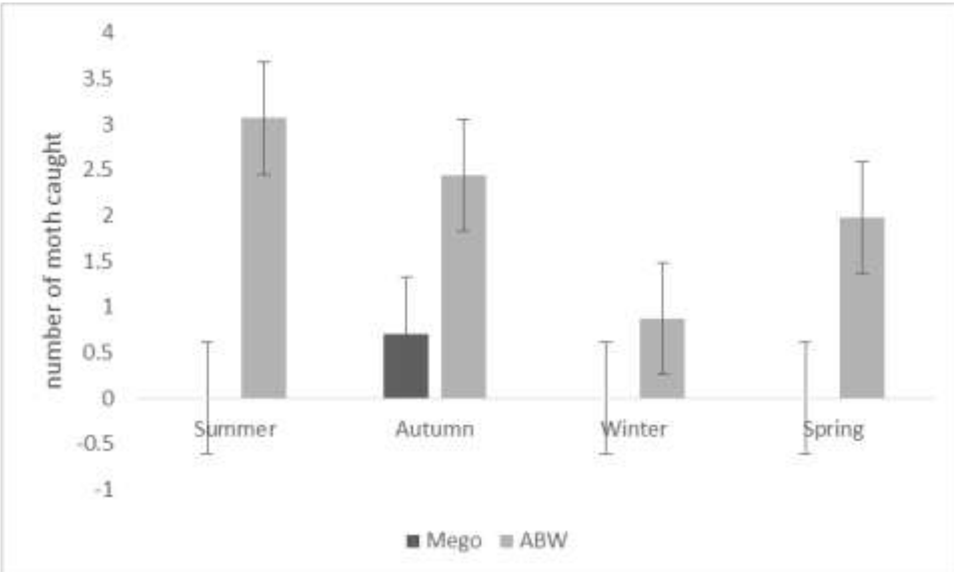

Figure 4.7 showing the effects of pheromone type on tip wilter moth in 4 seasons.

4.8 The Effects of Pheromone Type on Fruit Fly Moth in Different Seasons

There is an interaction between the season change, pheromone type and the number of Fruit fly trapped ($p=0.008$, $p <.001$). ABW had the lowest fruit fly count all four seasons and Mego had the highest fruit fly count in winter.

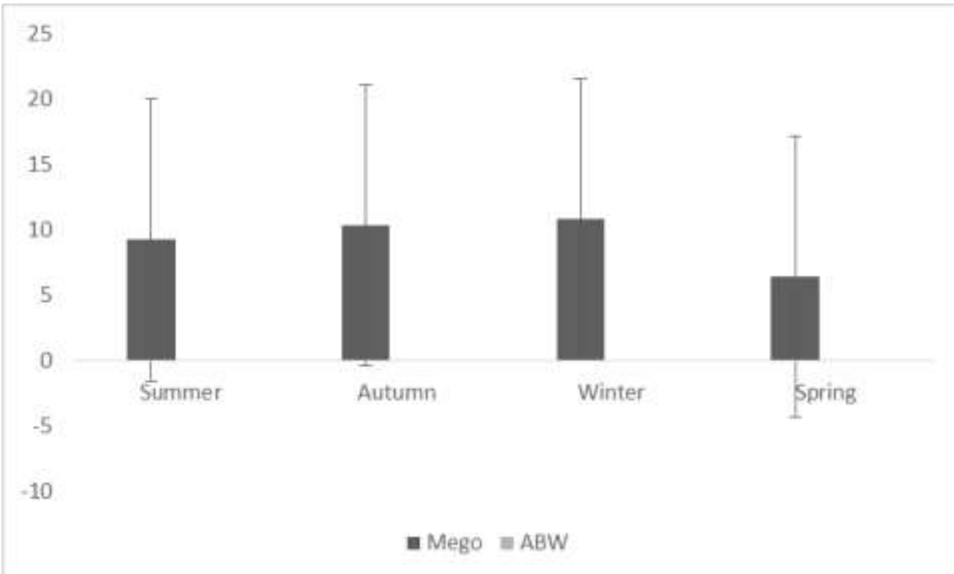

Figure 4.8 showing the effects of pheromone type on Fruit fly moth in 4 seasons.

4.9 The Effects of Pheromone Type on Sting Bugs Moth in Different Seasons

There is an interaction between the pheromone type and the number of Sting bugs trapped (p0.002).The number of Sting bugs caught decreased in autumn and increased in spring. The number of Fruit fly caught by ABW pheromone trap decreased from summer to spring as compared to Mego which caught highest Sting bugs in winter.

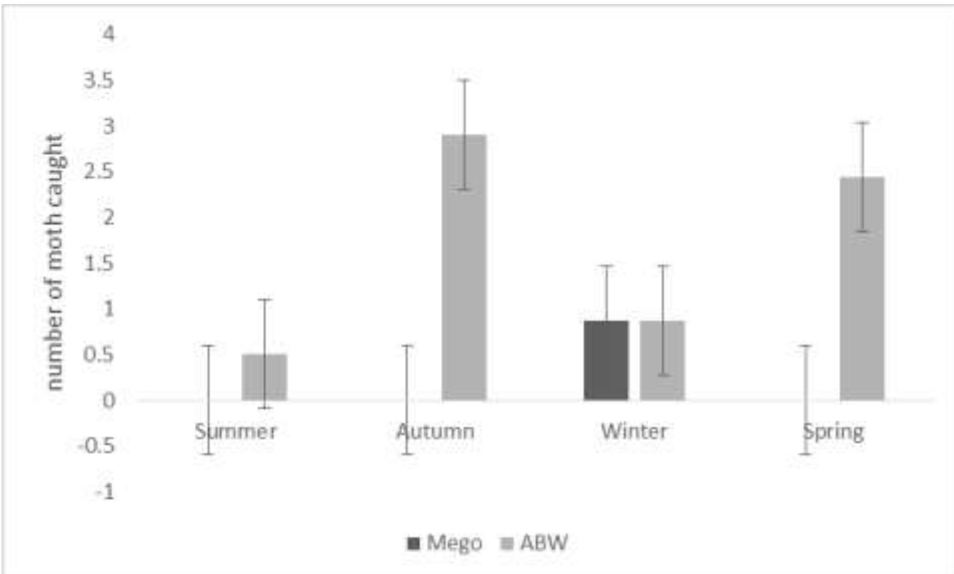

Figure 4.9 showing the effects of pheromone type on Sting bugs moth in 4 seasons.

4.10 The Effects of Pheromone Type on Capsid Moth in Different Seasons

There is an interaction between the season change, pheromone type and the number of Capsid trapped (p0.022, p<001). Mego had the lowest capsid counts in summer, autumn and winter. ABW traps gave the highest capsid count in winter.

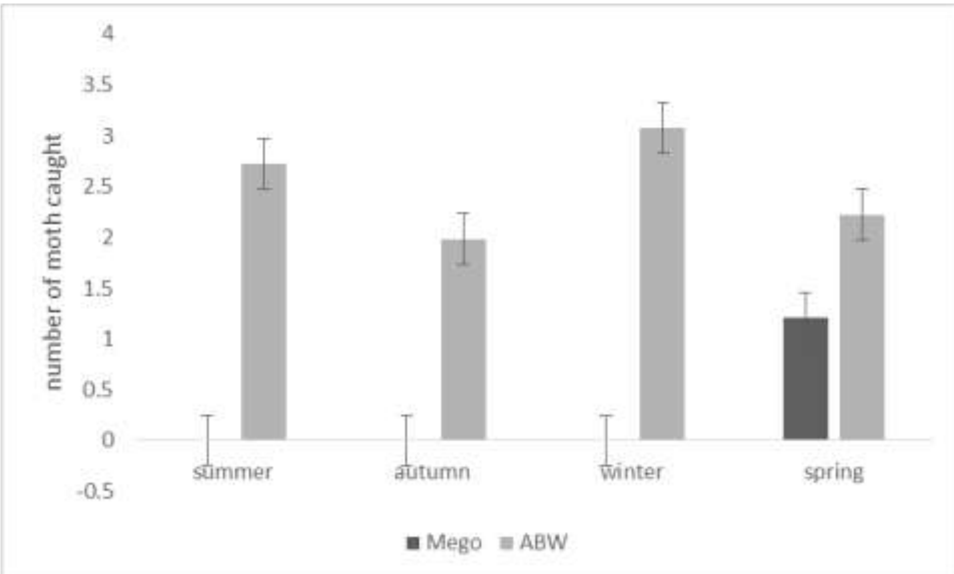

Figure 4.10 showing the effects of pheromone type on Capsid moth 4 seasons.

4.11 The Effects of Pheromone Type on Cutworm Moth in Different Seasons

There is an interaction between the season change, pheromone type, and the number of Cutworm trapped (p<.0.001). Mego gave the lowest count all four seasons and ABW traps gave the highest cutworm count in spring.

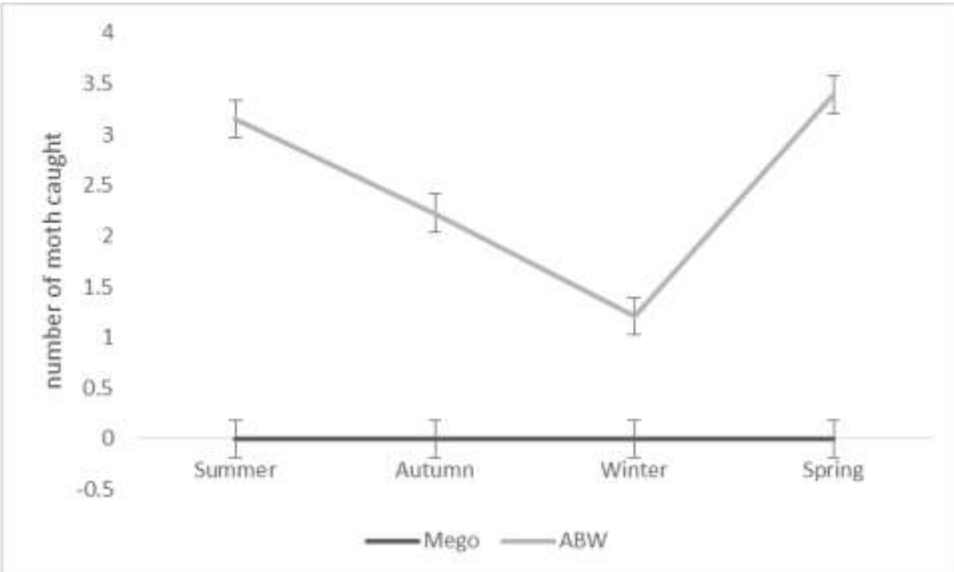

Figure 4.11 showing the effects of pheromone type on Cutworm moth in 4 seasons.

Chapter 5:

Discussion of results.

5.0 Trap types results discussion

5.1 African Bollworm

The African bollworm is highest in winter because in blueberries it favors mostly to live inside ripe berries and feeding on fruit sap. A ripe berry is very soft and easy for the African bollworm to penetrate. (Insect Science, 2023). Reaping of blueberries starts on 1 June which is winter. That is when African bollworms begin to increase mostly inside fruits and partly in folded leaves leaving veins perforated. However, the African bollworm count is low in autumn because blueberry bush might be still going through flowering stage and few fruit might still be growing. The bush might be having a lot of buds which have hard outer layer for the African bollworm to penetrate **(**Barnes et al., 2015)**.** Therefore, their moth is evidenced on the sticky traps. The bright colors of blue and yellow sticky rolls attracts many different insect moth and once they get in contact with the sticky rolls they get stuck and later dies

5.2 Sting bugs, Tip wilter, and Cutworm

The three insects are lowest in winter because they dislike cold winters. As of sting bugs when climate changes to a raised temperature they begin to increase but they dislike land that is too dry. Therefore, in summer that is why they are still low because it is characterized by very hot and dry temperatures. Sting bugs need water (Insect Science, 2023) and warm temperatures that is why there is a sharp increase count from winter to spring. Tip wilter insects usually come to spread in summer where they would be feeding on young leaves and shoots. It causes drying of terminal leaves and tip wilting in blueberries (Pritts, 2023). Cutworms are high in summer because they favor extremely dry conditions or wet conditions. Therefore, their moth is evidenced on sticky traps when caught.

5.3 Capsid

High in winter because they lay eggs in May and most varieties overwinter as adults. It feeds on developed fruit and young shoots. The green capsid is the most common and dangerous one.

5.4.0 Pheromone type discussion results.

5.4.1 African bollworm

Mego had the lowest bollworm counts in summer, autumn and winter. This is because the mego pherolure trap is used to control fruit flies but in rare cases few bollworms might get trapped also. The mego contains a bulb which is impregnated with a semiochemical and needs to be changed after every sixteen weeks (Insect Science2023). Mego attracts fruit flies such as the natal fruit fly *C rosa*, invader fly *B invadens*, *marula fly C cosyra* and *Medfly C capitata*. ABW trap consists of a tv pherolure which traps both males and females insect moth. ABW trap had the highest African bollworm count in spring because that is when the insect would be feeding on young shoots sprouting and ripe fruit.

5.4.2 Tip wilter and Cutworm

Mego had the lowest tip wilter in summer, winter and spring. This is because the mego pherolure is used to trap fruit flies and in some rare cases they trap few tip wilter. ABW had the highest count in summer because they will be feeding on young shoots and leaves. Tip wilter and Cutworms dislike cold temperatures that are why they are low in winter and as of cutworms, they begin to increase in spring as soon as temperatures get warm.

5.4.2 Fruit flies

Mego had the highest fruit fly count in winter. This is because fruit flies as the name says favors to feed on the ripe fruit. Reaping starts on 1 June in blueberries and that’s when most fruit flies are at its peak rise. ABW had the lowest fruit fly count because of lack of a mego pherolure which attracts fruit flies. However, in rare cases few fruit flies might get trapped in ABW types. (Berry World SA, n.d).

5.4.3 Sting bug

Abw types had the highest count in autumn. This is because sting bugs favor warm weather and wetness of the ground of the post rain season. They dislike land that is too dry therefore in summer they are few count of them due to harsh hot and dry weather conditions. Mego had the lowest count of them in summer. This is because mego pherolure is mainly used to control fruitflies however in rare cases few sting bugs might be trapped inside the mego.

5.4.4 Capsid

ABW traps had the highest count in winter. This is because they lay eggs in winter and feeds on developed fruit and young shoots.

Chapter 6:

Conclusion and Recommendation

6.1 Conclusion

From the study, it showed that trap types, pheromone type and season change interacted and had an effect on number of moth caught in different seasons. Trap types are far more effective on insect attraction efficiency than pheromone type. Trap type attract more number of insect pest than the pheromone type.

6.2 Recommendation

From this study I recommend farmers to effectively use trap all mego mostly in winter because that is when fruit flies are at highest count which might damage the blueberry fruit. I recommend farmers to use sticky rolls in winter in order to trap African bollworm moth because that is the season they begin to increase when the fruit is ripe. I recommend farmers to use ABW traps in winter to attract and kill capsid as they feed on developing fruit.

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Appendices:

Analysis of variance on Trap Type

Variate: Ballworm

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	2.250	2.250	0.44	
Block.*Units* stratum					
Colour	1	30.250	30.250	5.92	0.045
Season	3	426.750	142.250	27.85	<.001
Colour.Season	3	88.750	29.583	5.79	0.026
Residual	7	35.750	5.107		
Total	15	583.750			

Information summary

All terms orthogonal, none aliased.

Tables of means

Variate: Ballworm

Grand mean 15.62

Colour	1	2
	17.00	14.25

Season	1	2	3	4
	21.00	7.50	19.00	15.00

Colour	Season	1	2	3	4
1		21.50	9.00	24.00	13.50
2		20.50	6.00	14.00	16.50

Standard errors of means

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
e.s.e.	0.799	1.130	1.598

Standard errors of differences of means

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
s.e.d.	1.130	1.598	2.260

Least significant differences of means (5% level)

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
l.s.d.	2.672	3.779	5.344

Stratum standard errors and coefficients of variation

Variate: Ballworm

Stratum	d.f.	s.e.	cv%
Block	1	0.530	3.4
Block.*Units*	7	2.260	14.5

Analysis of variance

Variate: Tipwilter

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	7.56	7.56	0.36	
Block.*Units* stratum					
Colour	1	14.06	14.06	0.67	0.442
Season	3	778.69	259.56	12.28	0.004
Colour.Season	3	8.69	2.90	0.14	0.935
Residual	7	147.94	21.13		
Total	15	956.94			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

Block 1 *units* 5	6.7	s.e.	3.0
Block 2 *units* 5	-6.7	s.e.	3.0

Tables of means

Variate: Tipwilter

Grand mean 11.9

Colour	1	2
	11.0	12.9

Season	1	2	3	4
	21.2	16.0	4.2	6.2

Colour	Season	1	2	3	4
1		19.5	15.0	3.0	6.5
2		23.0	17.0	5.5	6.0

Standard errors of means

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
e.s.e.	1.63	2.30	3.25

Standard errors of differences of means

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
s.e.d.	2.30	3.25	4.60

Least significant differences of means (5% level)

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
l.s.d.	5.44	7.69	10.87

Stratum standard errors and coefficients of variation

Variate: Tipwilter

Stratum	d.f.	s.e.	cv%
Block	1	0.97	8.1
Block.*Units*	7	4.60	38.5

Analysis of variance

Variate: Stingbug

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	30.250	30.250	3.17	
Block.*Units* stratum					
Colour	1	0.250	0.250	0.03	0.876
Season	3	794.000	264.667	27.76	<.001
Colour.Season	3	4.750	1.583	0.17	0.916
Residual	7	66.750	9.536		
Total	15	896.000			

Information summary

All terms orthogonal, none aliased.

Tables of means

Variate: Stingbug

Grand mean 11.50

Colour	1	2
	11.62	11.38

Season	1	2	3	4
	7.00	20.00	2.50	16.50

Colour	Season	1	2	3	4
1		7.00	20.00	3.50	16.00
2		7.00	20.00	1.50	17.00

Standard errors of means

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
e.s.e.	1.092	1.544	2.184

Standard errors of differences of means

Table	Colour	Season	Colour Season

rep.	8	4	2
d.f.	7	7	7
s.e.d.	1.544	2.184	3.088

Least significant differences of means (5% level)

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
l.s.d.	3.651	5.163	7.302

Stratum standard errors and coefficients of variation

Variate: Stingbug

Stratum	d.f.	s.e.	cv%
Block	1	1.945	16.9
Block.*Units*	7	3.088	26.9

Analysis of variance

Variate: Capsid

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	3.06	3.06	0.29	
Block.*Units* stratum					
Colour	1	0.56	0.56	0.05	0.824
Season	3	627.19	209.06	19.93	<.001
Colour.Season	3	46.69	15.56	1.48	0.300
Residual	7	73.44	10.49		
Total	15	750.94			

Information summary

All terms orthogonal, none aliased.

Tables of means

Variate: Capsid

Grand mean 10.06

Colour	1	2
	10.25	9.88

Season	1	2	3	4
	5.00	6.50	20.75	8.00

Colour	Season	1	2	3	4
1		3.00	7.50	20.00	10.50
2		7.00	5.50	21.50	5.50

Standard errors of means

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
e.s.e.	1.145	1.619	2.290

Standard errors of differences of means

Table	Colour	Season	Colour Season

rep.	8	4	2
d.f.	7	7	7
s.e.d.	1.619	2.290	3.239

Least significant differences of means (5% level)

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
l.s.d.	3.829	5.416	7.659

Stratum standard errors and coefficients of variation

Variate: Capsid

Stratum	d.f.	s.e.	cv%
Block	1	0.619	6.1
Block.*Units*	7	3.239	32.2

Analysis of variance

Variate: Cutworm

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	20.25	20.25	1.69	
Block.*Units* stratum					
Colour	1	12.25	12.25	1.02	0.345
Season	3	434.25	144.75	12.10	0.004
Colour.Season	3	51.25	17.08	1.43	0.313
Residual	7	83.75	11.96		
Total	15	601.75			

Information summary

All terms orthogonal, none aliased.

Tables of means

Variate: Cutworm

Grand mean 15.12

Colour	1	2
	14.25	16.00

Season	1	2	3	4
	19.50	14.75	6.75	19.50

Colour	Season	1	2	3	4
1		17.00	12.50	6.00	21.50
2		22.00	17.00	7.50	17.50

Standard errors of means

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
e.s.e.	1.223	1.729	2.446

Standard errors of differences of means

Table	Colour	Season	Colour Season

rep.	8	4	2
d.f.	7	7	7
s.e.d.	1.729	2.446	3.459

Least significant differences of means (5% level)

Table	Colour	Season	Colour Season
rep.	8	4	2
d.f.	7	7	7
l.s.d.	4.090	5.783	8.179

Stratum standard errors and coefficients of variation

Variate: Cutworm

Stratum	d.f.	s.e.	cv%
Block	1	1.591	10.5
Block.*Units*	7	3.459	22.9

Analysis of variance on Pheromone Type

Variate: Ballworm

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	10.562	10.562	9.31	
Block.*Units* stratum					
Season	3	48.688	16.229	14.31	0.002
Pheromone	1	217.562	217.562	191.87	<.001
Season.Pheromone	3	32.188	10.729	9.46	0.007
Residual	7	7.938	1.134		
Total	15	316.938			

Information summary

All terms orthogonal, none aliased.

Tables of means

Variate: Ballworm

Grand mean 4.06

Season	1	2	3	4
	4.25	1.25	4.75	6.00

Pheromone	1	2
	0.38	7.75

Season	Pheromone 1	2
1	0.00	8.50
2	0.00	2.50
3	0.00	9.50
4	1.50	10.50

Standard errors of means

Table Season Pheromone Season

			Pheromone
rep.	4	8	2
d.f.	7	7	7
e.s.e.	0.532	0.376	0.753

Standard errors of differences of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
s.e.d.	0.753	0.532	1.065

Least significant differences of means (5% level)

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
l.s.d.	1.780	1.259	2.518

Stratum standard errors and coefficients of variation

Variate: Ballworm

Stratum	d.f.	s.e.	cv%
Block	1	1.149	28.3
Block.*Units*	7	1.065	26.2

Analysis of variance

Variate: Tipwilter

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	4.000	4.000	2.55	
Block.*Units* stratum					
Season	3	36.500	12.167	7.74	0.013
Pheromone	1	100.000	100.000	63.64	<.001
Season.Pheromone	3	33.500	11.167	7.11	0.016
Residual	7	11.000	1.571		
Total	15	185.000			

Information summary

All terms orthogonal, none aliased.

Tables of means

Variate: Tipwilter

Grand mean 2.75

Season	1	2	3	4
	4.75	3.50	0.75	2.00

Pheromone	1	2
	0.25	5.25

Season	Pheromone	1	2
1		0.00	9.50
2		1.00	6.00
3		0.00	1.50
4		0.00	4.00

Standard errors of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
e.s.e.	0.627	0.443	0.886

Standard errors of differences of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
s.e.d.	0.886	0.627	1.254

Least significant differences of means (5% level)

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
l.s.d.	2.096	1.482	2.964

Stratum standard errors and coefficients of variation

Variate: Tipwilter

Stratum	d.f.	s.e.	cv%
Block	1	0.707	25.7
Block.*Units*	7	1.254	45.6

Analysis of variance

Variate: Fruit_fly

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	72.2	72.2	0.62	
Block.*Units* stratum					
Season	3	3424.8	1141.6	9.87	0.007
Pheromone	1	31506.2	31506.2	272.36	<.001
Season.Pheromone	3	3424.8	1141.6	9.87	0.007
Residual	7	809.8	115.7		
Total	15	39237.8			

Information summary

All terms orthogonal, none aliased.

Tables of means

Variate: Fruit_fly

Grand mean 44.4

Season	1	2	3	4
	42.8	54.2	59.2	21.2

Pheromone	1	2
	88.8	0.0

Season	Pheromone	1	2
1		85.5	0.0
2		108.5	0.0
3		118.5	0.0
4		42.5	0.0

Standard errors of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
e.s.e.	5.38	3.80	7.61

Standard errors of differences of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
s.e.d.	7.61	5.38	10.76

Least significant differences of means (5% level)

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
l.s.d.	17.98	12.72	25.43

Stratum standard errors and coefficients of variation

Variate: Fruit_fly

Stratum	d.f.	s.e.	cv%
Block	1	3.01	6.8
Block.*Units*	7	10.76	24.2

Analysis of variance

Variate: Stingbug

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	2.250	2.250	1.62	
Block.*Units* stratum					
Season	3	36.500	12.167	8.74	0.009
Pheromone	1	56.250	56.250	40.38	<.001
Season.Pheromone	3	52.250	17.417	12.50	0.003
Residual	7	9.750	1.393		
Total	15	157.000			

Information summary

All terms orthogonal, none aliased.

Tables of means

Variate: Stingbug

Grand mean 2.25

Season	1	2	3	4
	0.25	4.25	1.50	3.00

Pheromone	1	2
	0.38	4.12

Season	Pheromone	1	2
1		0.00	0.50
2		0.00	8.50
3		1.50	1.50
4		0.00	6.00

Standard errors of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
e.s.e.	0.590	0.417	0.835

Standard errors of differences of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
s.e.d.	0.835	0.590	1.180

Least significant differences of means (5% level)

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
l.s.d.	1.973	1.395	2.791

Stratum standard errors and coefficients of variation

Variate: Stingbug

Stratum	d.f.	s.e.	cv%
Block	1	0.530	23.6
Block.*Units*	7	1.180	52.5

Analysis of variance

Variate: Capsid

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	0.562	0.562	0.44	
Block.*Units* stratum					
Season	3	15.688	5.229	4.10	0.057
Pheromone	1	150.062	150.062	117.53	<.001
Season.Pheromone	3	24.688	8.229	6.45	0.020
Residual	7	8.938	1.277		
Total	15	199.938			

Information summary

All terms orthogonal, none aliased.

Tables of means

Variate: Capsid

Grand mean 3.44

Season	1	2	3	4
	3.75	2.00	4.75	3.25

Pheromone	1	2
	0.38	6.50

Season	Pheromone 1	Pheromone 2
1	0.00	7.50
2	0.00	4.00
3	0.00	9.50
4	1.50	5.00

Standard errors of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
e.s.e.	0.565	0.399	0.799

Standard errors of differences of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
s.e.d.	0.799	0.565	1.130

Least significant differences of means (5% level)

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
l.s.d.	1.889	1.336	2.672

Stratum standard errors and coefficients of variation

Variate: Capsid

Stratum	d.f.	s.e.	cv%
Block	1	0.265	7.7
Block.*Units*	7	1.130	32.9

Analysis of variance

Variate: Cutworm

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	1	0.2500	0.2500	0.37	
Block.*Units* stratum					
Season	3	63.5000	21.1667	31.19	<.001
Pheromone	1	196.0000	196.0000	288.84	<.001
Season.Pheromone	3	63.5000	21.1667	31.19	<.001
Residual	7	4.7500	0.6786		
Total	15	328.0000			

Information summary

All terms orthogonal, none aliased.

Message: the following units have large residuals.

Block 1 *units* 6	1.12	s.e.	0.54
Block 2 *units* 6	-1.12	s.e.	0.54

Tables of means

Variate: Cutworm

Grand mean 3.50

Season	1	2	3	4
	5.00	2.50	0.75	5.75

Pheromone	1	2
	0.00	7.00

Season	Pheromone 1	2
1	0.00	10.00
2	0.00	5.00
3	0.00	1.50
4	0.00	11.50

Standard errors of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7

e.s.e.	0.412	0.291	0.582

Standard errors of differences of means

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
s.e.d.	0.582	0.412	0.824

Least significant differences of means (5% level)

Table	Season	Pheromone	Season Pheromone
rep.	4	8	2
d.f.	7	7	7
l.s.d.	1.377	0.974	1.948

Stratum standard errors and coefficients of variation

Variate: Cutworm

Stratum	d.f.	s.e.	cv%
Block	1	0.177	5.1
Block.*Units*	7	0.824	23.5