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MINISTRY OF EDUCATION

CURRICULUM PLANNING AND DEVELOPMENT DIVISION

CSEC Agricultural Science SBA Teachers' Training Manual

CSEC Agricultural Science Syllabus w.e.f. 2018

by

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Foreword

The Curriculum Planning and Development Division is pleased to develop this document as instructional material, intended to guide secondary school Agricultural Science teachers in the CSEC Agricultural Science School-Based Assessment (SBA). From 2018, the SBA portfolio requirements will be changed to investigative projects in crop and livestock production. Teachers have been clamouring for assistance in the implementation of the SBA to meet these new requirements. To this end, the Curriculum Planning and Development Division has been proactive in producing this document with the hope that it will positively contribute to teachers' professional development as well as students' academic success in CSEC Agricultural Science in Trinidad and Tobago and the wider Caribbean.

John Roopchan
Director Curriculum Development
Curriculum Planning & Development Division

Acknowledgements

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About this book

This book is intended as a guide to assist CSEC Agricultural Science teachers and students with the changes in the SBA requirements for the crop and animal production investigations in the revised CSEC Agricultural Science Syllabus which will be examined in 2018.

It contains two sample SBAs, a crop and a livestock investigative project, as well as sample data collection sheets and a draft mark scheme for marking these investigative reports. Section 1 contains the sample crop production investigative report and Section 2 is the sample livestock investigative report.

It is hoped that teachers would use the information in this Guide to assist their students in meeting the requirements for the CSEC Agricultural Science SBA investigative projects. Furthermore, teachers are encouraged to develop their own investigative projects in collaboration with their students.

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SECTION 1

SAMPLE
CROP INVESTIGATIVE PROJECT

FREEPORT HIGH SCHOOL

CSEC Agricultural Science (Single Award) Investigative Report

CROP INVESTIGATIVE PROJECT

Name of Student:	KAY MIKE
Student Registration No.:	1234567890
Name of School:	FREEPORT HIGH SCHOOL
Title of Project:	The Response of Pakchoi Plants to Fertilizer Application in a Clayey Loam Soil at Freeport High School, Trinidad & Tobago
Project Start Date:	1st November 2016
Project End Date:	15th December 2016

INTRODUCTION

Background

Pakchoi (*Brassica chinensis*) also known as Chinese cabbage is a leafy vegetable which is grown throughout Trinidad and Tobago. This crop can be eaten either cooked or raw. In Trinidad and Tobago, it is cooked and eaten as a green vegetable. Its leaves are rich in vitamins, minerals and dietary fibre (Ministry of Food Production, Land and Marine Affairs 2009).

Many varieties of pakchoi are grown in Trinidad and Tobago. Two common varieties grown are Joi Choi and Spoon Blade (Ministry of Food Production, Land and Marine Affairs 2009). Pakchoi vary in growth habit, agronomic practices and yield. Yields for pakchoi range from 4,988 to 29,927 kg/ha (Wanitprapha et al. 1992).

A review of the literature on pakchoi reveals a range of agronomic practices for growing this crop. These practices vary according to the cultivar, soil type and environmental conditions (Ministry of Food Production, Land and Marine Affairs 2009; Weever et al. 1998; Wanitprapha et al. 1992).

In Trinidad and Tobago, there are basically two methods of growing pakchoi: (a) growbox method and (b) field production. Growbox cultivation methods are described in *The Growbox System for Vegetables: A Producer's Manual (Ministry of Agriculture, Lands and Marine Resources* (2005). Field cultivation for pakchoi is described in Weever et al. (1998).

There are no guidelines for growing pakchoi at our school, and it has become necessary to develop guidelines for the growing of pakchoi at Freeport High School. This investigation was done to determine the response of pakchoi to fertilizer application at Freeport High School which has a clayey loam soil.

Problem Statement

The yield of pakchoi varies widely with crop production practices but the response of pakchoi to fertilizer application at Freeport High School is not known.

Hypothesis

Fertilizer application increases yield in pakchoi.
OR
The application of fertilizer to pakchoi increases yield.
OR
The yield of pakchoi increases with fertilizer application.

Aim

To determine the response of pakchoi to fertilizer application at Freeport High School.

METHODOLOGY

Materials, Tools and Equipment

Materials

30 pakchoi seedlings, 500 g fertilizer (30:10:10 NPK), 100 ml insecticide, 24 perforated plastic bags, 24 lolly sticks, 24 plant labels, 1 permanent marker

Tools and equipment

41 watering cans, 25 ml measuring cylinder, 2-kg kitchen scale, brushing cutlass, garden fork, hoe, garden spade, bucket, knife, garden hose, spray can, wheel barrow, plastic tray

Experimental Design

The experiment was conducted on a clayey loam soil at Freeport High School during the period 01 November to 15 December, 2016.

The experimental plot consisted of two beds labelled *Bed C* and *Bed T* with each bed measuring 1.8 m by 0.6 m. Bed C was the control bed and Bed T was the treatment bed.

The plants in Bed T were fertilized weekly with 5 g of 30:10:10 NPK fertilizer per plant, whereas the plants on Bed C were not fertilized.

Data Collection

The plants in the treatment bed (Bed T) were labelled from T1 to T12 and the plants in the control bed (Bed C) were labelled C1 to C12.

Over the experimental period, the following data were recorded in tables and used to plot graphs where appropriate:

Plant Survival

The number of surviving plants were counted and recorded each week until the end of the experiment.

Average Number of Leaves per Plant

The number of fully opened leaves on each plant was counted and recorded each week until the end of the experiment.

Yield

The yield was measured by obtaining the fresh weight of harvested pakchoi plants after removal of unwanted leaves.

Other Observations

The plants were closely monitored throughout the experimental period and all other observations were recorded e.g. colour of leaves, size of leaves and leaf damage.

Crop Production Practices

Soil Preparation and Formation of Beds

The land was cleared of existing weeds and bushes. The plant debris was removed from the land and placed in a compost heap. After the land was cleared, the soil was tilled using a garden fork, and it was refined using a hoe. Beds and drains were then formed. The beds measured 1.8 m long by 0.6 m wide and the drains measured 30 cm wide by 30 cm deep (Figures 1, 2 and 3).

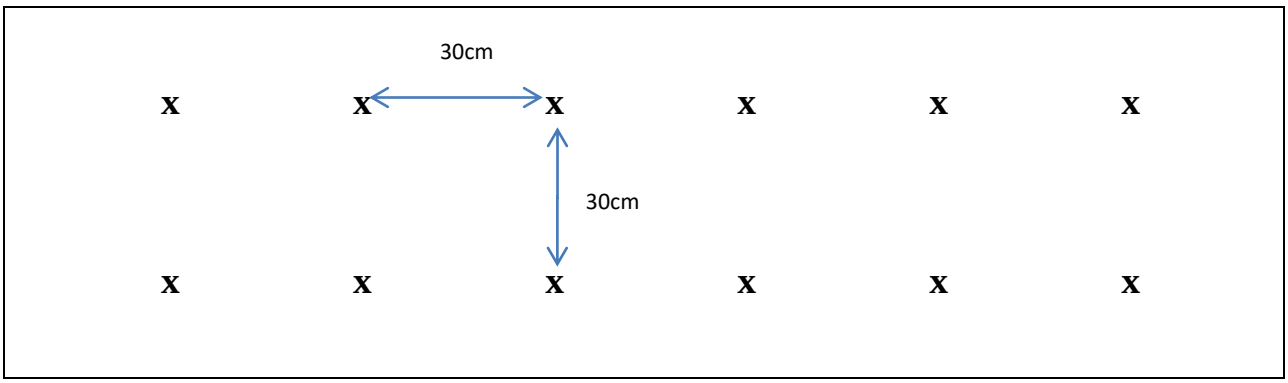
Figure 1: Bed after land was cleared of weeds

Figure 2: Bed after primary tillage was completed

Figure 3: Formation of beds and drains

Planting and Spacing

The crop was established using three-week-old seedlings. The seedlings were planted at a spacing of 30 cm by 30 cm (Figure 4). A five-cm hole was dug, one seedling was placed in the hole and the hole was refilled with soil. The soil was firmed around the base of the stem; care being taken not to crush the plant. Two rows of six seedlings per row were planted in each bed. After transplanting, the seedlings were watered using a watering can.



*KEY: "**X**" denotes position of pakchoi seedling*

Figure 4: Diagram showing planting arrangement of seedlings in a bed

Figure 5: Bed of established seedlings

Irrigation

The plants were watered to ensure that the soil was kept evenly moist throughout the experimental period (Figure 6).

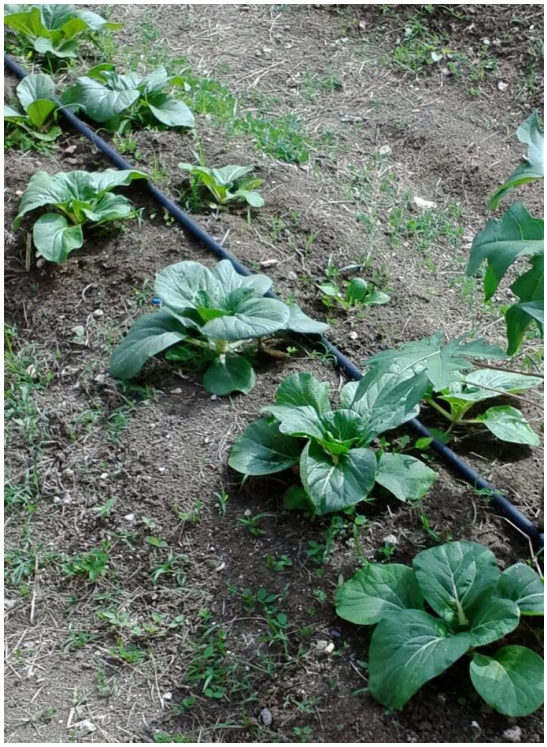


Figure 6: Crop irrigated using drip irrigation

Fertilizer Application

In the treatment bed, 5 g of 30:10:10 NPK fertilizer was applied per plant, beginning one week after transplanting. This was repeated weekly until the crop was harvested. The fertilizer was applied in a ring approximately 10 cm from the base of the plant.

In the control bed, no fertilizer was added for the duration of this experiment.

Weed Management

Weeds were controlled by hand weeding in both beds.

Pest and Disease Management

Pests and diseases were controlled by using appropriate pesticides at recommended application rates. The same amount of pesticide was applied to each plant on both beds.

Harvesting

The crop was harvested at six weeks after seedlings were transplanted. Plants were harvested by cutting off the stem at soil level. After harvesting, the plants were placed in plastic trays and taken to a cool location where the dried, damaged leaves were removed. The plants were then rinsed in clean water and placed in perforated plastic bags (Figure 7).

Figure 7: Cleaning and packaging harvested pakchoi

RESULTS

Plant Survival

Table 1 shows the number of plants that survived over the experimental period. In the treatment bed where the plants were fertilized with 5 g of 30:10:10 NPK fertilizer on a weekly basis, all 12 plants survived until the end of the experiment; whereas in the control bed, which did not receive any fertilizer, only eight plants survived until the end of the experimental period.

Table 1: Plant Survival over the Experimental Period

Time (weeks after transplanting)	Number of Plants that Survived	
	Treatment Bed	Control Bed
1	12	12
2	12	10
3	12	8
4	12	8
5	12	8
6	12	8

Average Number of Leaves per Plant

The average number of leaves per plant increased in both the treatment and control beds over the experimental period (Table 2). In the treatment bed, the average number of leaves per plant increased from 4 to 15; whereas in the control bed, the increase in the number of leaves per plant was from 4 to 10.

Table 2: Average number of leaves per plant over the experimental period

Time (weeks after transplanting)	Average Number of Leaves per Plant	
	Treatment Bed	Control Bed
1	4	4
2	7	5
3	11	7
4	13	8
5	14	9
6	15	10

Throughout the experiment, the plants in the treatment bed had a greater average number of leaves at any point in time when compared with plants in the control bed (Figure 8). In both the treatment and control beds, the greatest number of leaves was observed six weeks after transplanting.

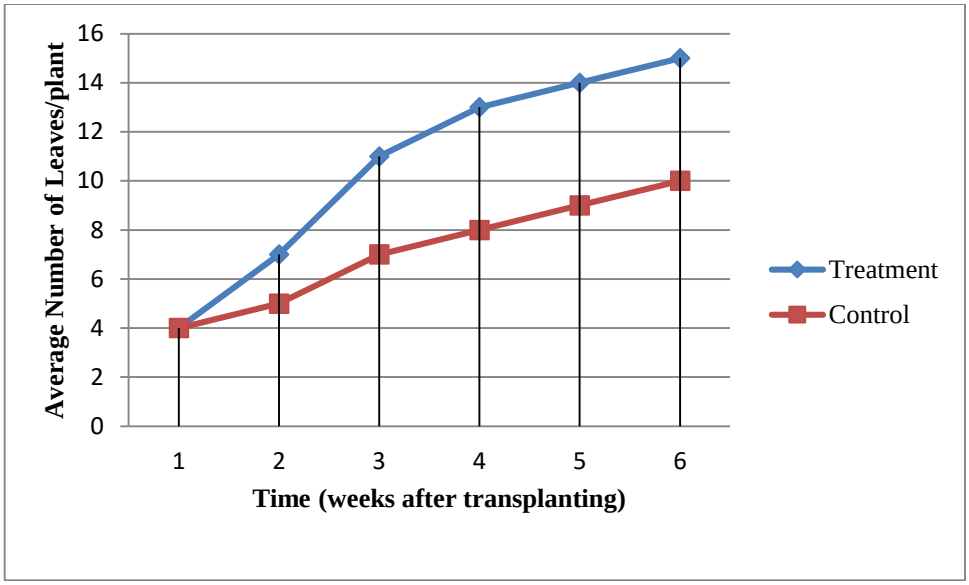


Figure 8: Graph showing average number of leaves/plant over the experimental period

Yield

The weight per head of pakchoi in the fertilized bed ranged from 450 g to 650 g with an average weight of 548.9 g (Table 3). The yield per head in the control bed ranged from 250 g to 375 g with an average weight of 278 g. The average yield per plant in the fertilized bed was 270.5 g (approximately 50%) more than that of the control bed.

Table 3: Fresh Weight of Harvested Crop

Treatment Bed		**Control Bed**	
Plant Number	**Fresh weight/plant (g)**	**Plant Number**	**Fresh weight/plant (g)**
T1	524	C1	250
T2	450	C2	275
T3	650	C3	375
T4	480	C4	260
T5	479	C5	265
T6	518	C6	-
T7	502	C7	260
T8	622	C8	270
T9	604	C9	-
T10	629	C10	269
T11	548	C11	-
T12	577	C12	-
Average weight	**548.5**	**Average weight**	**278.0**

Other observations

During this experiment it was also observed that the pakchoi leaves in the fertilized bed were larger and darker green in colour than those in the control bed (Figures 9 and 10).

Figure 9: Plant growing in the treatment bed

Figure 10: Plant growing in the control bed

DISCUSSION

Plant Survival

A greater number of plants survived in the fertilized bed. It would appear that the addition of fertilizer had a positive effect on plant survival in this experiment. This was probably due to the higher nutrient availability which caused the plants to better withstand environmental stresses when compared with the unfertilized plants. The compound fertilizer 30:10:10 NPK has a total nutrient content of 50% of which 30% is nitrogen, 10% is phosphorus and 10% is potassium. The plants which were fertilized had more phosphorus available and this was responsible for promoting better root growth and development (Ramharracksingh 2011) which probably allowed for greater nutrient uptake. In the control bed which received no fertilizer, there may have been less nutrients available resulting in lower plant growth. Furthermore, this reduced nutrient availability may have caused lower overall plant nutrient status resulting in plant death.

Average Number of Leaves per Plant

Plants in the fertilized bed had more leaves. The mean number of leaves at harvest was 15 whereas in the control there were 10. The reason for the increased number of leaves in the fertilized bed was probably due to higher nitrogen level in the soil which caused the plants to grow more vigorously, thus producing more leaves (Ramharracksingh 2011).

Yield

Plants in the fertilized beds had a greater yield with 50% greater fresh weight than those in the control bed. The heavier pakchoi weight found in the fertilized bed was attributed to the greater number of leaves and the larger leaf size. These results indicated that the addition of fertilizer had a positive effect on pakchoi yield in this experiment.

The greener leaves in the treatment bed was probably due to the availability of higher levels of nitrogen. Nitrogen is needed for protein synthesis and this is responsible for promoting plant growth (Ramharracksingh, 2011) which was higher in the treatment bed and resulted in greener leaves.

CONCLUSION, RECOMMENDATIONS AND LIMITATIONS

Conclusion

It can be concluded that the application of fertilizer increased the yield of pakchoi plants in a clayey loam soil at Freeport High School.

Recommendations

Based on the results of this experiment, it is recommended that pakchoi planted at Freeport High School Garden be fertilized with 5 g of 30:10:10 NPK fertilizer on a weekly basis. However, the experiment should be repeated using more plants to confirm this finding. The experiment should also be repeated at different seasons.

Limitations

Some of the limitations of this experiment are:

1. The number of plants grown were too few to make a generalized statement.
2. This experiment was not replicated.
3. This experiment was done only at one time of the year, at one location and does not take seasonality into account.
4. The results could have been affected by varying field conditions such as uneven soil moisture content.

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Weever, F., J. Johnson, L. M. Phillip-Neri, Y. McIntosh, N. Henery, W. Archer, L. Vickerie, and E. O'D. Williams. 1998. *Agricultural Science in Secondary Schools in Guyana Book 1*. Georgetown: Ministry of Education.

COST ANALYSIS

The cost analysis was done for the 12 pakchoi plants grown in the control bed. These plants were not treated with any fertilizers but were managed in the same manner as the plants in the fertilized bed.

Complete Budget

This section includes the Projected Income, Projected Expenditure and Projected Profit/Loss, for this activity.

Projected Income

Table 4 shows that the projected income for this project is $60.00 from the intended sale of 12 heads of pakchoi at $5.00 per head.

Table 4: Projected Income

Item	Quantity	Unit Cost ($)	Total Cost ($)
Pakchoi	12 heads	5.00*	60.00
		Total Projected Income	**60.00**

**Source: National Agricultural Market Information System*

Projected Expenditure

The estimated expenditure for this project is $15.60.

Table 5: Projected Expenditure

Item	Quantity	Unit Cost	Total Cost ($)
Pakchoi Seedlings	12	$0.25 each	3.00
Insecticide	50ml	$24.00 per 100ml bottle	12.00
Plastic bag	12	$0.05 each	0.60
		Total Projected Expenditure	**15.60**

Projected Profit/Loss

The projected profit or was calculated using the formula below:

Projected Profit/Loss = Projected Income – Projected Expenditure
= $60.00 - $15.60
= $44.40

A projected profit of $44.40 is expected to be earned from pakchoi grown in the control bed.

Actual Income-Expenditure Statement

This section comprises the Actual Income, Actual Expenditure and the Actual Profit/Loss for this activity.

Actual Income

The actual income earned from the pakchoi grown in the control bed was $32.00

Table 6: Actual Income

Item	Quantity	Unit Cost	Total Cost ($)
Pakchoi	8 only	$4.00	32.00
		Total Income	**32.00**

Actual Expenditure

The actual expenditure for the pakchoi grown in the control bed was $18.40

Table 7: Actual Expenditure

Item	Quantity	Unit Cost	Total Cost ($)
Pakchoi seedlings	12	$0.50 each	6.00
Insecticide	1 bottle	$12.00 per 100ml bottle	12.00
Plastic bag	8	$0.05 each	0.40
		Total Expenditure	**18.40**

Actual Profit/Loss

The projected profit/loss was calculated using the formula below:

Actual Profit/Loss = Total Income – Total Expenditure
= $32.00 - $18.40
= $13.60

This activity generated a profit of $13.60 from the sale of pakchoi grown in the control bed.

Comparison of Projected and Actual Income, Expenditure and Profit/Loss

A comparison of the Projected and Actual Income, Expenditure and Profit/Loss is shown in Table 8.

Table 8: Comparison of Projected and Actual Income, Expenditure and Profit/Loss

	Projected ($)	**Actual ($)**	**Difference between Projected and Actual ($)**
Income	60.00	32.00	-28.00
Expenditure	15.60	18.40	2.80
Profit/Loss	44.40	13.60	-30.80

The actual income from this project based on the sale of 8 plants grown in the control bed was $32.00. This was $28.00 less than what was projected in the Budget. The reduced income was due to following reasons:

1. Four pakchoi plants died leaving only eight plants for sale.
2. The projected selling price of pakchoi based on market information from the website namistt.com was $5.00 per head but because the pakchoi heads were smaller than anticipated they were sold at a cheaper price of $4.00 per head. This was 20% less than the anticipated price.

The actual expenditure for this project was $18.40 based on the sale of eight pakchoi heads. This was $2.80 more than what was anticipated in the budget. More money was spent than was planned for the following reasons:

1. The cost of the seedlings had increased by 25¢ per seedling so an additional $3.00 more was spent.
2. In the budget, the estimated cost of 50 ml insecticide was $12.00. A larger bottle was obtained for the same price but no additional money was saved for this item. However, the remaining insecticide can be used whenever this crop is re-planted in the future and additional money can be saved at that time.

The profit made from this activity was $13.60 which was $30.80 less than was expected. The projected profit was $44.40 but, due to lower income and increased expenditure, the actual profit was reduced.

Conclusion

Producing pakchoi for sale can be a profitable enterprise but in order to maximize profits, expenditure must be minimized and harvesting timed to coincide with periods when market prices are high.

Recommendation

In order to have a more profitable project in the future the following strategies are recommended:

1. Plant more pakchoi plants.
2. Review market trends to determine when to plant pakchoi to take advantage of high prices.

3. Add fertilizer to the plants to ensure that they grow stronger, healthier and look more attractive to consumers.
4. Reap the crop as soon as it gets to a desirable size so additional money would not have to be spent on labour and resources for taking care of the crop for a longer period than is required.

Reference

Trinidad and Tobago, National Agricultural Market Information System. undated. Historical Monthly Average Retail Prices 2016. National Agricultural Marketing and Development Corporation. http://www.namistt.com/ (accessed January 11, 2017).

APPENDIX 1: DATA COLLECTION SHEETS FOR CROP INVESTIGATION

Plant Survivability

BED	Plant Number	No. of Plants Surviving (Weeks After Transplanting)					
		1	2	3	4	5	6
TREATMENT	T 1						
	T 2						
	T 3						
	T 4						
	T 5						
	T 6						
	T 7						
	T 8						
	T 9						
	T 10						
	T 11						
	T 12						
	Total No. of Plants Surviving						
CONTROL	C 1						
	C 2						
	C 3						
	C 4						
	C 5						
	C 6						
	C 7						
	C 8						
	C 9						
	C 10						
	C 11						
	C 12						
	Total No. of Plants Surviving						

Number of Leaves per Plant

BED	Plant Number	Number of Leaves per Plant (Weeks After Transplanting)					
		1	2	3	4	5	6
TREATMENT	T 1						
	T 2						
	T 3						
	T 4						
	T 5						
	T 6						
	T 7						
	T 8						
	T 9						
	T 10						
	T 11						
	T 12						
	Average Number of Leaves						
CONTROL	C 1						
	C 2						
	C 3						
	C 4						
	C 5						
	C 6						
	C 7						
	C 8						
	C 9						
	C 10						
	C 11						
	C 12						
	Average Number of Leaves						

Fresh Weight of Harvested Crop

TREATMENT BED		CONTROL BED	
Plant Number	**Fresh Weight of Harvested Crop (g/plant)**	**Plant Number**	**Fresh Weight of Harvested Crop (g/plant)**
T 1		**C 1**	
T 2		**C 2**	
T 3		**C 3**	
T 4		**C 4**	
T 5		**C 5**	
T 6		**C 6**	
T 7		**C 7**	
T 8		**C 8**	
T 9		**C 9**	
T 10		**C 10**	
T 11		**C 11**	
T 12		**C 12**	
Average Weight (g)		**Average Weight (g)**	

APPENDIX 2: DRAFT MARK SCHEME FOR CROP INVESTIGATION

Item	Descriptor		Marks	
			Total	Awarded
Introduction (2)	Name of Student		-	-
	Student Registration Number		-	-
	Name of School		-	-
	Title of Project		-	-
	Start Date		-	-
	End Date		-	-
	Table of Contents		-	-
	Problem Statement clearly written		1	
	Hypothesis clearly written		-	-
	Aim clearly written		1	
Methodology (6)	Accurate List of Materials, Tools and Equipment Used		1	
	Valid Experimental Design		1	
	Data Collection		1	
	Production Practices / Activities (2)	5 or more activities described	2	
		1 to 4 activities described	1	
		No activities described	0	
	3 or more photographs showing student engaged in this investigation		1	
Results (4)	Collected relevant data		1	
	Presentation of Results – appropriate format used		1	
	Interpretation of results (2)	Fully interprets results	2	
		Partially interprets results	1	
		Did not attempt to interpret results	0	
Discussion (3)	Fully discussed findings with reference to relevant supporting literature		3	
	Partially discussed findings with reference to relevant supporting literature		2	
	Discussed finding with no supporting literature		1	
	Did not attempt to discuss findings		0	
Conclusion, Limitation & Recommendations (3)	Conclusion		1	
	Limitations		1	
	Recommendations for improvement		1	
Presentation (1)	Less than 5 spelling and grammatical errors contained in the report		1	
References (1)	At least 2 references properly cited		1	
		TOTAL (Investigative Report)	**20 ÷ 2 = 10**	… ÷ 2 = ….
Cost Analysis (10)	Complete Budget	Projected Income – output, price, total	1	
		Projected Expenditure – inputs, price, total	1	
		Surplus/Shortfall correctly calculated	1	
	Actual Income & Expenditure	Income/Sale of Produce – quantity, price, total	1	
		Expenditure – quantity, price, total	1	
		Surplus/Shortfall correctly calculated	1	
	Comparison of Projected and Actual - Income - Expenditure - Surplus/shortfall	Provides a full and accurate comparison of all 3 parameters	4	
		Partially compares all 3 parameters	3	
		Correctly compares any 2 parameters	2	
		Correctly compares any 1 parameter	1	
		Did not attempt to compare any parameter	0	
		TOTAL (Cost Analysis)	**10**	

PART 2

SAMPLE LIVESTOCK INVESTIGATIVE PROJECT

FREEPORT HIGH SCHOOL

CSEC Agricultural Science (Single Award) Investigative Report

LIVESTOCK INVESTIGATIVE PROJECT

Name of Student:	KAY MIKE
Student Registration No.:	1234567890
Name of School:	FREEPORT HIGH SCHOOL
Title of Project:	The Effect of Spacing on Broiler Production at Freeport High School, Trinidad & Tobago
Project Start Date:	9th January 2017
Project End Date:	27th February 2017

INTRODUCTION

Background

Broilers are a breed of domesticated fowl (*Gallus gallus domesticus*) that are reared specifically for meat production. Popular breeds of broilers include Hyline, Vantress-Cross, Shaver, Peterson and Star Cross. Some common characteristics of broiler birds are: white feathers, yellow skin and rapid weight gain reaching a marketable size of about 2 kg in 5 to 7 weeks of age.

Broiler meat is a very good source of protein and does not contain high levels of saturated fat like other popular sources of animal protein such as mutton and beef. In Trinidad and Tobago, consumers spend $1.2 billion each year on broiler meat (Douglas 2017).

Broiler farming can be a good source of income for many farmers. Some farmers engage in broiler production on a large scale. Broilers are marketed as live birds or as dressed carcasses (Weever et al. 1998).

A review of the literature on broiler production reveals a wide range of management practices. These practices vary according to breed, system of management, husbandry practices and environmental conditions (Aviagen 2015; Hubbard 2015; Cobb-Vantress 2013; Hi-Pro Feeds n.d.)

Generally, there are three main systems of rearing broilers: (a) extensive or free-range system, (b) semi-intensive or run system and (c) intensive or deep-litter system. Traditionally, at Freeport High School, broilers are reared intensively using the deep-litter system as described by Aviagen (2015), Hubbard (2015) and Cobb-Vantress (2013). There is a need however to fine-tune these guidelines specific to conditions at Freeport High School. This experiment seeks to investigate the effect of spacing on broiler production at Freeport High School.

Problem Statement

The response of broilers to spacing at Freeport High School is not known.

Hypothesis

Broiler weight gain is affected by spacing.
OR
Spacing affects broiler weight gain.

Aim

To determine the effect of spacing on weight gain in broilers and so determine the optimum spacing for broiler birds at Freeport High School.

METHODOLOGY

Materials, Tools and Equipment

Materials

30 broiler chicks, starter feed, finisher feed, de-wormer, electrolyte, wood shavings, disinfectant

Tools and Equipment

Wire mesh, infrared lamp, feeders, waterers, broom, 10 kg weighing scale, rake, bucket, shovel, broiler weighing cone, garden hose, wheel barrow, electric fan, feed bags

Experimental Design

This investigation was conducted in the poultry pen at Freeport High School during the period 09 January to 27 February, 2017.

Twenty-four, one-day old broiler chicks were reared in a brooder for three weeks. After brooding, the poultry pen was divided into two sections, labelled *Section C* and *Section T*. Section C was the 'control section' and Section T was the 'treatment section'. The treatment section allowed for rearing the birds at a spacing of 0.14 m^2 (1.5ft^2) per bird and the control section allowed a spacing of 0.09 m^2 (1ft^2) per bird. Twelve brooded chicks were randomly selected and placed in each section of the pen.

Data Collection

Over the experimental period, the following data were recorded in tables and used to plot graphs where appropriate:

Broiler Liveability

The number of surviving broilers were recorded each week until the end of the experiment.

Average Feed Consumption per bird per week

The feed was weighed prior to filling the feeders and the weight of feed given each week was recorded until the end of the experiment. Average feed consumption was calculated as follows:

$$\text{Average feed consumption/bird/week} = \frac{\text{Weekly Feed Consumption}}{\text{Number of birds}}$$

Broiler Live Weight

All the birds were weighed at the start of the experiment and each week thereafter the weight of the birds was recorded until the end of the experiment.

Feed Conversion Ratio (FCR)

FCR for each set of birds was calculated using the following formula (Ramharrackingh, 2011):

$$\text{Feed Conversion Ratio} = \frac{\text{Weekly Feed Intake (kg)}}{\text{Weekly Weight Gain (kg)}}$$

Other Observations
The broilers were closely monitored throughout the investigative period and all other observations were recorded.

Broiler Production Practices

Spacing
A spacing of 0.14 m^2 (1.5ft^2) was allowed for each bird in the treatment section and in the control section the birds were reared at 0.09 m^2 (1ft^2) per bird. In this investigation, 12 birds were reared in each section and the floor space was calculated accordingly with allowances being made for one feeder and one waterer in each section. The spaces allocated for the feeder and waterer were 0.13m^2 and 0.15m^2, respectively.

The dimensions of the treatment section were 1.4 m by 1.4 m with an area of 1.96 m^2 (21.10ft^2) and the control section were 1.17 m by 1.17 m with an area of 1.36 m^2 (14.64ft^2) respectively.

Housing
Fluorescent lights were provided at nights to enable the birds to feed continuously. During hot days, wall-mounted fans were also used to keep the poultry pen well ventilated.

Nutrition
The growing birds were fed starter feed for up to four weeks. During the last three days of the fourth week, finisher feed was gradually introduced by mixing it with starter feed in increasing amounts. The birds had access to clean, fresh water at all times.

Figure 1: Filling the feeder with finisher feed

Litter Management
The litter was turned regularly using a rake, and all caked and/or wet litter was removed and replaced with clean wood shavings. The litter that was removed was placed in a compost heap.

Figure 2: Turning litter

Health Management

Feeders and waterers were cleaned and sanitized regularly. At the end of the Week 4, the birds were de-wormed using an appropriate de-wormer at the recommended rate.

Sale of Birds

At the end of seven weeks, the birds were ready for market. They were sold as live birds. They were caught, weighed and their weights were recorded.

Figure 3: Weighing birds

RESULTS

Broiler Liveability

Table 1 shows the number of broilers that survived over the trial period. All 12 birds survived in both the treatment and control sections of the pen.

Table 1: Liveability over the Experimental Period

Time (weeks)	Number of Broilers Survived	
	Treatment Section	Control Section
3	12	12
4	12	12
5	12	12
6	12	12
7	12	12

Feed Consumption

Table 2 shows the average weekly feed consumption of birds reared in the treatment and control sections of the pen. The average weekly feed consumption per bird increased from 692 g to 1,298 g for the birds reared at the wider spacing (treatment) and from 700 g to 1,280 g for those at the closer spacing (control). On average the birds reared in the treatment section ate 26 g less feed than those in the control section.

Table 2: Average Feed Consumption/Bird over the Experimental Period

Time (weeks)	Average Feed Consumption per bird (g)	
	Treatment Section	Control Section
3	692	700
4	990	990
5	1112	1100
6	1255	1260
7	1298	1280
Total Average Feed Consumption/bird	**5939**	**5965**

Figure 4 shows that in both the treatment and control sections of the pen, average broiler feed consumption increased throughout the investigative period and displayed a similar pattern. Initially, from Week 3 to Week 4 feed consumption increased rapidly; then from Weeks 5 to 7 feed consumption continued to increase but at a reduced rate.

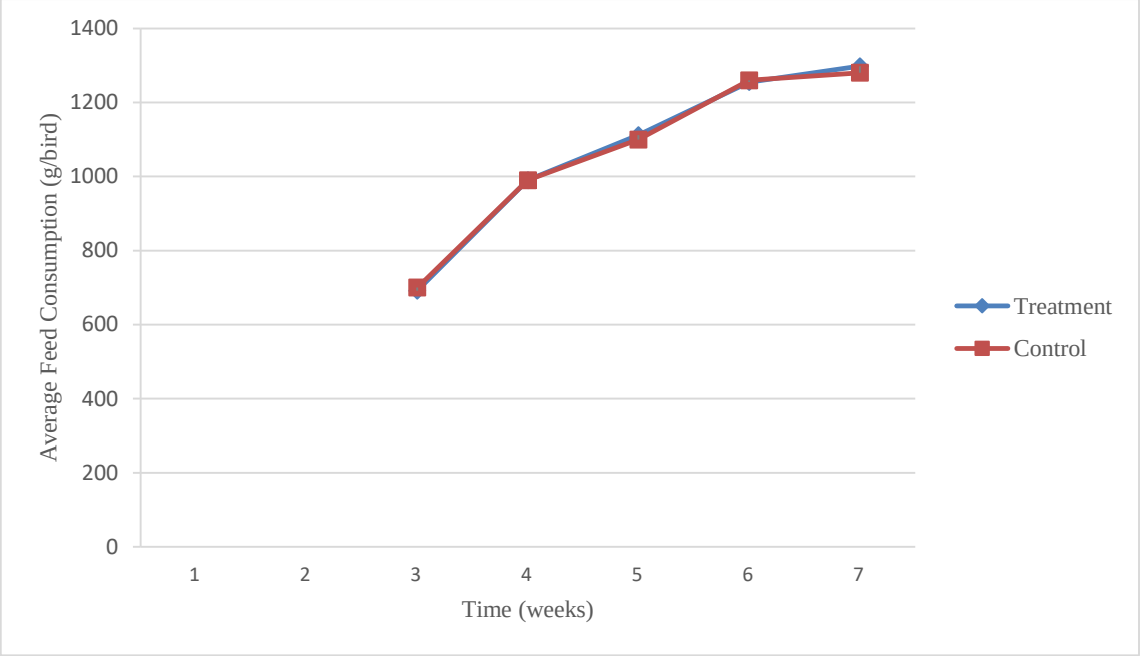

Figure 4: Average Weekly Feed Consumption/Bird

Broiler Live Weight

Table 3 shows that as the birds got older their average weight increased reaching a maximum of 2800 g/bird and 2795g/bird for birds reared at the wider and closer spacing respectively, at 7 weeks.

Table 3: Average Live Weight/Bird over the Experimental Period

Time (weeks)	Average Weight (g)	
	Treatment Section	Control Section
3	1100	1080
4	1700	1665
5	2200	2185
6	2600	2595
7	2800	2795

In both the treatment and control sections of the pen, the birds displayed similar weight gain patterns. The most rapid weight gain occurred from Week 3 to Week 5. Thereafter birds continued to gain weight but at a reduced rate (Figure 5).

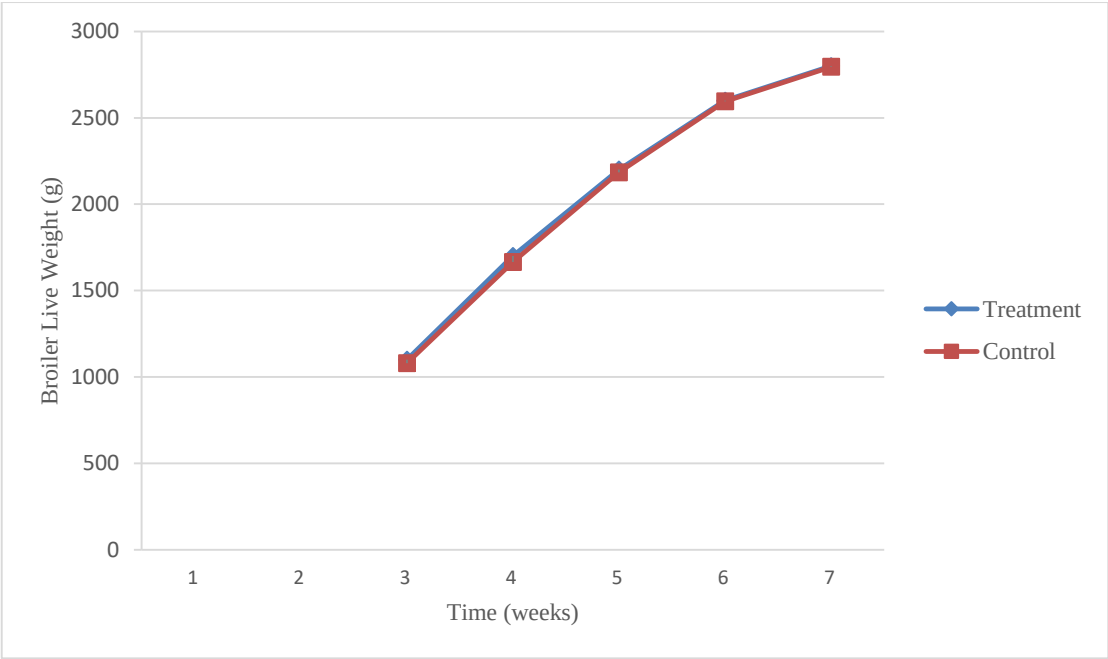

Figure 5: Average Live Weight

Feed Conversion Ratio (FCR)

Table 4 shows that as the birds got older FCR increased. At the start of this experiment, the birds in both the treatment and control sections had the same FCR of 1.4:1. At the end of the trial in Week 7, the FCR for the birds reared at the wider spacing was 6.6 and for those at the closer spacing it was 6.4. The overall FCR for both the treatment and control was the same (FCR = 2.1).

Table 4: Broiler Feed Conversion Ratio over the Experimental Period

Time (weeks)	Feed Conversion Ratio	
	Treatment Section	Control Section
3	1.4:1	1.4:1
4	1.7:1	1.7:1
5	2.2:1	2.1:1
6	3.5:1	3.1:1
7	6.6:1	6.4:1
Overall	**2.1:1**	**2.1:1**

Figure 6 shows that birds reared in the treatment and control sections of the pen had the same FCR trends. Initially, the FCR at Week 3 was 1:4 which increased slowly to approximately 3:1 by Week 6, thereafter it rose rapidly to above 6:1.

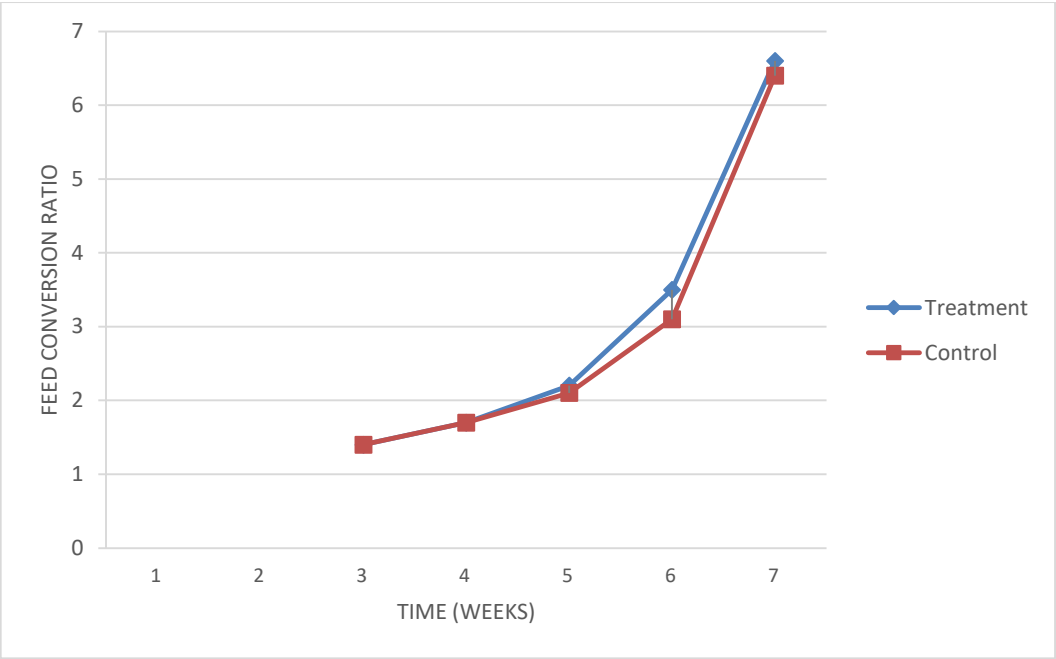

Figure 6: Feed Conversion Ratio

Other Observations

It was observed that from Week 6 onwards, the broiler birds at the closer spacing started pecking at each other, had more difficulty moving around the pen and were panting. The litter was wetter and more compacted than in the treatment section where the birds were reared at the wider spacing.

DISCUSSION

Broiler Liveability

All the broiler birds survived in both the treatment and control sections of the pen during the experiment. This was probably due to the fact that both the wider and closer spacing were adequate for the growth and development of the birds.

The addition of the water soluble electrolyte to the drinking water probably contributed to the high liveability by providing the necessary vitamins and minerals needed for the health, growth and development of the birds. It also would have counteracted the negative effect of stress and maintained hydration of the chicks during the early brooding stages (Vitalyte, n.d.).

Feed Consumption

In both the treatment and control sections, the birds ate approximately the same amount of feed (5.9 kg) and displayed the same feed intake pattern. It would appear that spacing had no effect on the quantity of feed consumed by the birds in this experiment. In both the treatment and control sections, the birds had equal access to feed and water. The total feed consumed by the birds in each section was much more than the 4.7 kg observed by Jacob and Pescatore (2012) for seven-week-old broilers having a live weight of 2.4 kg in Kentucky, United States of America.

Broiler Live Weight

In both the treatment and control sections, the broiler birds displayed similar live weight gain patterns and by the end of the experiment at seven weeks, the average live weight of the birds was approximately the same (2.8 kg). These results indicated that the spacing had no effect on broiler live weight gain in this experiment. The live weight of the birds in this experiment was 0.4 kg more than was reported by Jacob and Pescatore (2012) for seven-week-old broilers in Kentucky, United States of America. This was probably due to the greater amount of feed consumed.

Feed Conversion Ratio (FCR)

At Week 3 and Week 4, the FCR for the birds in the treatment section (0.14 m^2 /bird) was the same as the FCR for those in the control section (0.09 m^2/bird). This was probably due to the birds having more than adequate space to move around thereby using the same amount of energy and eating the same amount of feed. The overall FCR for both the treatment and the control sections was the same (2.1:1); this was higher than what was reported by Fairchild (2005) who found that birds reared at 0.09 m^2 had an FCR of 1.83:1 with an average body weight of 2.72 kg.

Other Observations

The pecking of the birds seen in the control section (0.09 m^2/bird) may have been due to stress induced by the closer spacing since the birds were bigger and had a relatively smaller space for them to move around (Ragoonanan 2001)

The reduced space in the control section may have led to difficulty in movement for the birds since these birds were stocked at a closer spacing (Fairchild 2005). This reduced movement within this section would also contribute to the litter in the section being wetter and more compacted.

CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

Conclusion

It can be concluded that rearing birds at the wider spacing of 0.14 m^2 (1.5ft^2) per bird has no effect on broiler production at Freeport High School.

Recommendation

Based on the results of this investigation, it is recommended that broilers can be reared at the closer spacing of 0.09 m^2 (1ft^2) per bird. This spacing will allow the farmer to maximize his stocking density, thereby improving the efficiency of his operations. However, the study needs to be repeated and more broilers used.

Limitations

Some of the limitations of this investigation are:

1. This experiment was limited to only two spacing requirements. This was too narrow a range to determine the optimum spacing requirement for broiler birds at Freeport High School.
2. The number of birds reared were too few to make a generalized statement.
3. This trial was not replicated. This trial was only done at one time of the year and did not take seasonality into account.
4. The results could have been affected by varying environmental conditions due to inappropriate trial design.

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COST ANALYSIS

A cost analysis was done on broilers reared in the control section which consisted of 12 birds. These birds were reared at the recommended spacing of 0.09 m^2 per bird and were managed according to the production practices previously outlined in this document.

Complete Budget

This section comprises a complete budget. It includes the Projected Income, Projected Expenditure and Projected Profit/Loss.

Projected Income

Table 5 shows that the projected income for this project as $655.20 from the intended sale of 12 broiler birds sold at $20 per kg live weight with a projected average weight of 2.73kg each.

Table 5: Projected Income for Broilers Reared at Freeport High School

Item	Quantity	Unit Cost ($)	Total Cost ($)
12 broiler birds weighing 2.73kg (6lbs) each	32.76kg live weight	$20.00 per kg live weight*	655.20
		Total Projected Income	**655.20**

**Source: National Agricultural Market Information System*

Projected Expenditure

The estimated expenditure for this project is $542.00.

Table 6: Projected Expenditure for Broilers Reared at Freeport High School

Item	Quantity	Unit Cost ($)	Total Cost ($)
Broiler chicks	12	10.00	120.00
Broiler Starter	½ bag	240.00	120.00
Broiler Finisher	1 bag	225.00	225.00
Electrolyte	1 pack	10.00	10.00
De-wormer	1 pack	7.00	7.00
Sawdust	2 bags	30.00	60.00
		Total Projected Expenditure	**542.00**

Projected Profit/Loss

The projected profit/loss was calculated using the formula below:

Projected Profit/Loss = Projected Income – Projected Expenditure
= $655.20 - $542.00
= $113.20

Projected Profit = $113.20

In this broiler project we expect to make a profit of $113.20 from the sale of 12 live broiler birds.

Actual Income-Expenditure Statement

This section comprises the Actual Income, Actual Expenditure and the Actual Profit/Loss.

Actual Income

The actual income earned for this project was $403.20

Table 7: Actual Income for Broilers Reared at Freeport High School

Item	Quantity	Unit Cost ($)	Total Cost ($)
12 broiler birds weighing 2.8kg each	33.6 kg live weight	$12.00 per kg live weight	403.20
		Total Income	**403.20**

Actual Expenditure

The actual expenditure for this project was $572.00

Table 8: Actual Expenditure for Broilers Reared at Freeport High School

Item	Quantity	Unit Cost ($)	Total Cost ($)
Broiler chicks	12	10.00	120.00
Broiler Starter	½ bag	240.00	120.00
Broiler Finisher	1 bag	225.00	225.00
Electrolyte	1 pack	$10.00	10.00
De-wormer	1 pack	$7.00	7.00
Sawdust	2 bags	$20.00	40.00
		Total Projected Expenditure	**522.00**

Actual Profit/Loss

In this project we made a loss of $118.80.

Actual Profit / Loss = Total Income – Total Expenditure

= $403.20- $522.00

= -$118.80

Actual Loss = $118.80

Comparison of Projected and Actual Income, Expenditure and Profit/Loss

This section compares the Projected and Actual Income, Expenditure and Profit/Loss for broiler reared at Freeport High School (Table 9).

Table 9: Comparison of Projected and Actual Income, Expenditure and Profit/Loss for Broilers Reared at Freeport High School

	Projected ($)	**Actual ($)**	**Difference between Projected and Actual ($)**
Income	655.20	403.20	-252.00
Expenditure	542.00	522.00	-20.00
Profit / Loss	113.20	- 118.80	-232.00

The actual income from this project was $403.20 which was $252.00 less than what was projected in the budget. The reduced income was due to following reason:

- The projected selling price of the broilers was $20.00/kg live weight but at the time of selling, the market price was drastically reduced to $12.00/kg which was only 60% of the anticipated selling price.

The actual expenditure for this project was $522.00 which was $20.00 less than anticipated in the budget. Less money was spent than was planned for the following reason:

- The cost of the sawdust was cheaper; it was reduced from $30.00/bag to $20.00/bag at the time of purchasing.

This activity resulted in a loss of $118.80 which was $232.00 less than expected. It was projected that this activity would generate a profit of $113.20 but due to a decrease in actual income of $403.20, a substantial loss was realized.

Conclusion

Selling broiler birds as live birds is not a profitable activity especially during periods when market prices are low.

Recommendations

In order to have a profitable project in the future, the following strategies are recommended:

1. Review market trends to determine when to rear broilers to take advantage of high prices
2. Sell the birds as soon as they get to marketable weight so that additional money would not have to be spent on feeding the birds at a time when the Feed Conversion Ratio is high.
3. After birds are sold, compost the litter and sell as manure.
4. Sell the birds as dressed birds to earn additional income through value added activities.

References

Trinidad and Tobago, National Agricultural Market Information System. undated. Historical Monthly Average Retail Prices 2016. National Agricultural Marketing and Development Corporation. http://www.namistt.com/ (accessed January 11, 2017).

APPENDIX 1: DATA COLLECTION SHEET FOR BROILER INVESTIGATION

Broiler Feed Consumption

Week	Total Feed Consumption (g/week)	
	TREATMENT	CONTROL
3		
4		
5		
6		
7		
Total Weight		

Week	Average Feed Consumption (g/bird/week)	
	TREATMENT	CONTROL
3		
4		
5		
6		
7		

Broiler Survival

Week	Broiler Liveability	
	TREATMENT	CONTROL
3		
4		
5		
6		
7		

Broiler Live Weight

Week	Total Live Weight of birds (g/week)	
	TREATMENT	CONTROL
3		
4		
5		
6		
7		
Total Weight		

Week	Average Live Weight of Birds (g/bird/week)	
	TREATMENT	CONTROL
3		
4		
5		
6		
7		

APPENDIX 2: DRAFT MARK SCHEME FOR LIVESTOCK INVESTIGATION

Item	Descriptor		Marks	
			Total	Awarded
Introduction (2)	Name of Student		-	-
	Student Registration Number		-	-
	Name of School		-	-
	Title of Project		-	-
	Start Date		-	-
	End Date		-	-
	Table of Contents		-	-
	Problem Statement clearly written		1	
	Hypothesis clearly written		-	-
	Aim clearly written		1	
Methodology (6)	Accurate List of Materials, Tools and Equipment Used		1	
	Valid Experimental Design		1	
	Data Collection		1	
	Production Practices / Activities (2)	5 or more activities described	2	
		1 to 4 activities described	1	
		No activities described	0	
	3 or more photographs showing student engaged in this investigation		1	
Results (4)	Collected relevant data		1	
	Presentation of Results – appropriate format used		1	
	Interpretation of results (2)	Fully interprets results	2	
		Partially interprets results	1	
		Did not attempt to interpret results	0	
Discussion (3)	Fully discussed findings with reference to relevant supporting literature		3	
	Partially discussed findings with reference to relevant supporting literature		2	
	Discussed finding with no supporting literature		1	
	Did not attempt to discuss findings		0	
Conclusion, Limitation & Recommendations (3)	Conclusion		1	
	Limitations		1	
	Recommendations for improvement		1	
Presentation (1)	Less than 5 spelling and grammatical errors contained in the report		1	
References (1)	At least 2 references properly cited		1	
		TOTAL (Investigative Report)	**20 ÷ 2 = 10**	… **÷ 2 =** ….
Cost Analysis (10)	Complete Budget	Projected Income – output, price, total	1	
		Projected Expenditure – inputs, price, total	1	
		Surplus/Shortfall correctly calculated	1	
	Actual Income & Expenditure	Income/Sale of Produce – quantity, price, total	1	
		Expenditure – quantity, price, total	1	
		Surplus/Shortfall correctly calculated	1	
	Comparison of Projected and Actual - Income - Expenditure - Surplus/shortfall	Provides a full and accurate comparison of all 3 parameters	4	
		Partially compares all 3 parameters	3	
		Correctly compares any 2 parameters	2	
		Correctly compares any 1 parameter	1	
		Did not attempt to compare any parameter	0	
		TOTAL (Cost Analysis)	**10**	