EVALUATION OF DIFFERENT MODELS FOR VEGETABLES PRODUCTION ON ROOFTOP GARDEN

A THESIS

BY

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Certificate

*This is to certify that the thesis entitled '**Evaluation of Different Models for Vegetables Production On Rooftop Garden**' submitted to the Faculty of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Dhaka-1207, in partial fulfillment of the requirements for the degree of **Master of Science** in **Agroforestry and Environmental Science**, embodies the result of a piece of genuine research work carried out by **Md. Abdul Mannan**, Reg. No. **15-06970** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledgement.

Dated: December 2016

Place: Dhaka, Bangladesh

Professor Dr. Md. Forhad Hossain

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Dedicated

This thesis is dedicated to my supportive and hilarious wife, Sumana Yasmin and my two amazing child, Akib Zayed & Sarah Tasneem.

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EVALUATION OF DIFFERENT MODELS FOR VEGETABLES PRODUCTION ON ROOFTOP GARDEN

BY

MD. ABDUL MANNAN

ABSTRACT

Roof top garden is a practice for cultivation of crops on roof top on a building either in peri-urban or urban areas. The experiment was conducted at roof top of Mushroom laboratory, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during July 2016 to June 2017. The experiment was laid out in Completely Randomized Design (CRD) having single factors with three replications. Nine treatment of this experiment were T_1= Plastic box 1, T_2= Plastic box 2, T_3= Plastic box 3, T_4= Plastic box 4, T_5= Plastic box 5, T_6= Plastic box 6, T_7= Plastic box 7, T_8= Half drum, T_9= Sac/ Multilayer box and three roof top garden models viz., Model 1, Model 2, Model 3 included in the study. Each model consists of 22 type vegetables. Considering the 3 models, there were a narrow difference in term of vegetable yield and prices. In terms of vegetables yield during one year from a 100 sqft area, Model 2 produced the maximum yield (76 kg) followed by Model 1 (68.5 kg), while lowest by Model 3 (66.5 kg). The yield variation was very narrow due to maximum vegetables were same in among 3 model, while only 2-3 vegetables were differed. In terms of vegetable price, Model 2 obtained the maximum (2374 tk) followed by Model 1 (2278 tk), while minimum was from Model 3 (2116 tk).The main cause behind it was the number of vegetables was same (22) in all models. Just rearrangement the vegetables within the treatments and type of production system viz., single cropping, inter cropping and relay cropping. So, on a roof garden from a 100 sqft area, anybody can follow any model preferably Model 2 and Model 1, which vegetable price (2374 tk, 2278 tk, respectively) and yield (76 kg, 68.5 kg, respectively) were higher. This study was just 1-year result, so after another year trial it may be concluded which model is best in terms of yield and price.

LIST OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF ABBREVIATED TERMS

BARI	Bangladesh Agricultural Research Institute
CRD	Completely Randomized Design
et al.	And others
FAO	Food and Agriculture Organization
Fig.	Figure
HRC	Horticulture Research Centre
kg	Kilogram
RTG	Roof Top Garden
RAJUK	Rajdhani Unnayan Kartripakha
Tk.	Taka
UN	United State
UA	Urban Agriculture

Chapter I: Introduction

CHAPTER I
INTRODUCTION

Dhaka is one of the fastest growing megacities and most densely populated cities in the world and experienced a higher rate of urban growth in recent decades. The Greater Dhaka has a population of over 18 million as of 2016, while the city itself has a population estimated at about 8.5 million.The density of 23,234 people is per square kilometer within a total area of 300 square kilometers. Due to unrestrained urban growth, it will be the fourth largest urban agglomeration of the world with a population of 160.4 million by 2015, up from the 2013 estimate of 156.5 million (World Population Prospects, 2016). The city is considered the largest in all of Bangladesh and the overall metropolitan area is the 9th largest city in the entire world. So, the city is facing incredible problems associated with unplanned development, high level of poverty, social vulnerability, inadequate infrastructure, lack of social services, poor quality of physical and social environment, and inefficient urban management (UN, 1999). In urbanization process, about 20 percent vegetation cover in 1989 and gradually decreased to 15.5 percent to 7.3 percent in the year 2002 to 2010. For the residents of Dhaka, there is limited access to fresh, healthy, culturally appropriate and affordable food. While nearly almost half of the people of Dhaka are food insecure. Overall, a much higher percentage are unable to obtain fresh and nutritious produce (Food Security in Bangladesh, 2005). Urban agriculture promotion and its sustainability seem to be a remedy to such situations, whole augmenting income and employment opportunities in the cities (Barua and Ikbal, 2012).

Urban agriculture is the practice of cultivating, processing, and distributing food in or around a village, town, or city. Urban agriculture can also involve animal husbandry, aquaculture, agroforestry,urban beekeeping and horticulture. These activities occur in peri-urban areas as well urban areas (FAO 2013).Rooftop garden is a part of urban agriculture. A rooftop garden is a garden on the roof of a building. Besides thedecorative benefit, roof plantings may provide food, temperature control, hydrological benefits, architectural enhancement, habitats or corridors for wildlife, recreational opportunities, and in large scale it may even have ecological benefits (Sajjaduzzaman *et al.*, 2005).In Bangladesh ornamental plant, fruit trees, flowering plants and vegetables are mostly growth on rooftops. Temperatures around the building can be lowered in the summer. It can be further insulated from the cold in the winter. The roof life can be extended by protecting its from various weather. This trend will continue as the need to reduce carbon emissions increases.

It's found in a research that 60% space of total Dhaka city occupied with bare roof with no other extensive usage. However, these benefits are difficult to realize because the lands which have traditionally been used for agriculture within our urban areas are in high demand and vulnerable to development. As a result, rooftop agriculture, in containers or on flat roofs has become an attractive possibility.

Roof top gardening is suitable for vegetable cultivation in our country.Vegetableplay an important role in balance diet of human beings. Vegetables are rich sources of vitamins and minerals and also a good source of carbohydrates. Vegetable of Bangladesh are grouped into summer, winter and year round on the basis of growing season. Total production of vegetable meets up to 45-50% of the requirement of the country.Proper model for vegetable production on rooftop garden food production can be increase. However, the practically of green roof agriculture has not been extensively tested. This is a new research work that ever performed. In this research work the suitability of three models for vegetable production on rooftop conditions was evaluated.

Considering the above factors, the present experiment was undertaken to study the following objectives:

- Development of suitable model on roof top for vegetable production
- To accommodate maximum vegetable in a small unit area (10 m^2 / 100 sqft).

Chapter II: Review Literature

CHAPTER II
REVIEW OF LITERATURE

The aim of this chapter is to describe the review of the past research conducted in line of the major focus of the study. The literature Review chapter consists of two sections. The first section illustrated the rooftop garden for green roof. In the second section, articulated urban agriculture, its role and importance. Literatures related of rooftop gardens and vegetable which were collected through reviewing of journals, thesis, internet browsing, reports, newspapers, periodicals and other form of publications are presented in this chapter under the following headings-

2.1 Rooftop garden for green roof

A rooftop garden is a garden on the roof of a building. The practice of cultivating food on the rooftop of buildings is sometimes referred to as rooftop farming. Rooftop farming is usually done using green roof, hydroponics, aeroponics or air-dyponics systems of container gardens. Various plants can grow in a rooftop garden depending on the weather conditions in that particular region. Rooftop gardening can provide a yearly income through the vegetables and fruits cultivation. Rooftop gardens are a tremendously easy, cathartic, accessible way to grow plants and vegetables and they come with a number of benefits.

In Bangladesh ornamental plant, fruit trees, flowering plants vegetables are mostly used. Green roofs can help in the absorption of carbon dioxide and help reduce air pollution area's aesthetics will be enhanced and property value could be increased.Economically there are no additional land costs.Temperatures around the building can be decreased in the summer. A green roof can be further insulated from the cold in the winter.

Quamruzzaman (2015) reported the thermal benefits of roof gardens and the overall techniques and farming procedures of vegetables, fruits, flowers/ornamental plants and multipurpose use of Roof garden.

Orsini*et al*., (2014) was carried out a study addressing the quantification of the potential of rooftop vegetable production in the city of Bologna (Italy) as related to its citizen's needs. The potential benefits to urban biodiversity and ecosystem service provision were estimated. RTGs could provide more than 12,000 t year^{-1} vegetables to Bologna, satisfying 77 % of the inhabitants' requirements.

Sharmin S. (2013) has conducted a case study on Green roof, an innovative approach to achieve environmental sustainability and thermal comfort in Dhaka. She found that green areas (like parks, gardens, vegetation, play fields) in cities and urban lands are being replaced with impervious surfaces resulting from pressure of urbanization which is creating extensive and varied urban environmental degradations. She was focuses on this paper about the potential of extensive over deep intensive green roof in safeguarding the urban built environment and improving environmental sustainability and the local thermal comfort level in dense urban areas of Dhaka city.

Mostafa (2013) found in his study of present status of rooftop gardening in Sylhet City Corporation of Bangladesh that each gardener was interested in rising of rooftop garden because they think that home gardens could help them to income and save money 29.8% respondents were involved in gardening for economic purpose, 54.9% respondents for environmental amelioration, 95.3% was in favor of mental satisfaction, aesthetic value (82.5%) and leisure time activity (87.8%).

R. Rashid *et. al.,* (2010), experimented the thermal performance of rooftop garden in a six storied building established in 2003. She found that the temperature of this building is 3°C lower than other surrounding buildings andthis Green application canreduce the indoor air temperature 6.8°C from outdoor during the hottest summer period.

Islam (2002) reported that urban population in the cities of developing countries are growing rapidly which also means the number of low-income consumers is increasing. Because of this, food insecurity in these cities is increasing. Urban agriculture (UA) contributes to food security by increasing the supply of food and by enhancing the quality of perishable foods reaching urban consumers. In this study he was try to identify the potential for and barriers to UA with reference to rooftop gardening (RTG) and to explore strategies to promote food security in Dhaka.

Shuvo (2000) proposed for a conceptual framework based on an obligatory on-site adaptation to ‘long-term greening’ and discussed how this framework should enable a sustainable mainstreaming of the violated constructions ensuring fiscal benefits for RAJUK, building owner and the ‘green industry’ alike.

Krupka (1992) reported rooftop gardening aspects and town planning aspects, developments in techniques of roof gardening in the last decade, the ecological value of growing plants on buildings, habitat restrictionsof vegetation on buildings,planning factors, prevention of damage to buildings, preparation and protection of the habitat and different forms of greening.

Bennett (2003); Maas *et al.,* (2006) reported that RTGs, while being aesthetically appealing, can contribute to biodiversity in the urban environment, achieve more sustainable conditions, including those necessary for the production of food and improve the overall quality of urban life .

2.2 Urban Agriculture, its role and importance

Urban agriculture is the practice of cultivating, processing, and distributing food in or around a village, town, or city. Urban agriculture can also involve animal husbandry, aquaculture, agro forestry, urban beekeeping and horticulture. These activities occur in peri-urban areas as well urban areas. The current global urban population is expected to double by 2050, with 90 percent of urban growth taking place in developing countries. This rapid urbanization process goes hand in hand with increasing food insecurity and malnutrition in cities, especially on the side of the simultaneously increasing population living in poverty. Local governments have to develop new strategies to ensure water, energy and food security for their citizens.

Urban agriculture is an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows and raises, processes and distributes a diversity of food and non-food products, (re-)using largely human and material resources, products and services found in andaround that urban area, andin turn supplying human and material resources, products and services largely to that urban area. (Mougeot, 2001)

Hodgon, *et al.,* (2011) reported that urban agriculture is much more than private gardens and community gardens, and many communities are beginning to see the promise of other forms of urban agriculture. This paper is to provide funders with an overview of urban agriculture and its various forms, dimensions, and benefits; its connections to the broader community-based food system

Tabassum and Sharmin (2010) observed that less green space creates urban heat island effect due to more reflection of solar radiation and outdoor temperature of denser built up area in Dhaka is 1˚C-1.5˚C higher than the immediate urban zones with less green coverage and also can be higher at a range of 0.5-1˚C than the average meteorological record. This research also showed that indoor temperature of residential buildings in less green covered neighborhoods rise at a range of 1˚C-2˚C thus creates thermal discomfort among occupants.

Moustier (2007) provides an extensive summary of the importance of urban agriculture in 14 African and Asian cities. Among the results they found that 90 % of all vegetables consumed in Dar es Salaam (Jacobi *et al.*, 2000) and 60 % of vegetables consumed in Dakar (Mbaye and Moustier 2000) originate from urban agriculture.

Islam (2001) reported that urban agriculture in the cities of developing countries are growing rapidly which also means the number of low-income consumers is increasing. Because of food insecurity in these cities is increasing. Urban agriculture (UA) contributes to food security by increasing the supply of food and by enhancing the quality of perishable foods reaching urban consumers.

Chapter III: Materials and Methods

CHAPTER III
MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment.

3.1 Location of the experiment field

The experiment was conducted at roof top garden ofMushroom laboratory, Horticulture Research Centre, Bangladesh Agricultural Research Institute, Gazipur during the period from July 2016 to June 2017. The location of the experimental site was at 24.00^{0}N latitude and 90.25^{0}E longitude.

3.2 Climate

The climate of the experimental site is subtropical, characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during the rest of the year (Rabi season). The average minimum and maximum temperature were18.37^{0}C and 29.37^{0}C and the average relative humidity varied from 55.55 to 75.70 %.Rabi season is characterized by plenty of sunshine. The maximum and minimum temperature, humidity rainfall and soil temperature during the study period were collected from the Bangladesh Meteorological Department (Climate Division) and have been presented in Appendix I.

3.3 Soil

The soil of the experimental pots was sandy clay loam in texture having a pH range around 6.0. The soil was acidic being characterized by poor fertility status and impeded internal drainage. Soil samples of the experimental plots were collected before initiation of the experiment fromdepths of 0-15 cm and analyzed in the laboratory. Physical and chemical properties of the soil of the experimental field are presented in appendix II.

3.4 Planting materials collection

The seeds of 22 types of vegetables were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Treatments of the experiment

Model 1:	T_1-Plastic box 1 (Red amaranth, Radish, Brinjal, Gimakalmi,Cucumber), T_2-Plastic box 2 (Gimakalmi, Cauliflower, Red amaranth, Stem amaranth), T_3-Plastic box 3 (Red amaranth, Turnip , Tomato, Red amaranth, Okra), T_4-Plastic box 4 (Red amaranth, Radish, Carrot, Indian spinach, Okra), T_5-Plastic box 5 (Gimakalmi, Bottle gourd, Spinach, Cucumber), T_6-Plasticbox 6 (Gimakalmi, Country bean, Spinach, Bitter gourd, Gimakalmi), T_7-Plastic box 7 (Year round Chilli, Coriander), T_8-Half drum (Aroid (Kochu), Gimakalmi), T_9-Sac (Red amaranth, Lettuce, Bottle gourd leaf, Indian spinach, Bunching onion).
Model 2:	T_1-Plastic box 1 (Red amaranth, Knolkhol, Tomato, Gimakalmi, Okra), T_2-Plastic box 2 (Red amaranth, Radish, Brinjal, Red amaranth, Cucumber), T_3-Plastic box 3 (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi), T_4-Plastic box 4 (Red amaranth, Capsicum, Carrot, Indian spinach, Okra), T_5-Plastic box 5 (Gimakalmi, Bottle gourd, Spinach, Red amaranth, Yard long bean), T_6-Plastic box 6 (Gimakalmi, Country bean, Red amaranth, Bitter gourd, Gimakalmi), T_7-Plastic box 7 (Year round Chilli, Red amaranth, Coriander), T_8-Half drum (Aroid (Kochu), Red amaranth, Lettuce), T_9-Multilayer box (Coriander, Gimakalmi, Indian spinach, Bottle gourd leaf, Red amaranth).
Model 3:	T_1-Plastic box 1 (Red amaranth, Turnip, Brinjal, Gimakalmi, Okra), T_2-Plastic box 2 (Red amaranth, Radish, Tomato, Red amaranth, Cucumber), T_3-Plastic box 3 (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi), T_4-Plastic box 4 (Red amaranth, Carrot, Capsicum, Okra),

	T_5-Plastic box 5 (Gimakalmi, Country bean, Spinach, Red amaranth, Yard long bean), T_6-Plastic box 6 (Gimakalmi, Bottle gourd, Coriander, Indian spinach, Gimakalmi), T_7-Plastic box 7 (Year round Chilli, Coriander, Red amaranth), T_8-Half drum (Aroid (Kochu), Red amaranth), T_9-Multilayer box (Lettuce, Gimakalmi, Indian spinach, Bottle gourd leaf, Red amaranth).

3.6 Design and layout of the experiment

The experiment was laid out in Completely Randomized Design (CRD) having single factors with three replications. An area of 29.7 m x 29.7 m was divided into three equal blocks. Each block was consists of 3 Model. There were 9 unit plots in the experiment. The size of each treatment (model) was 3.3 m x 3.3 m, which accommodated 9 combinations.

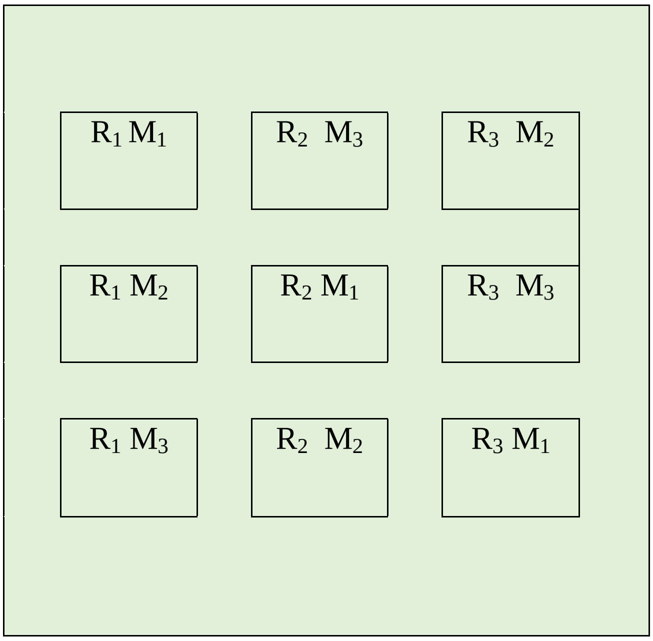
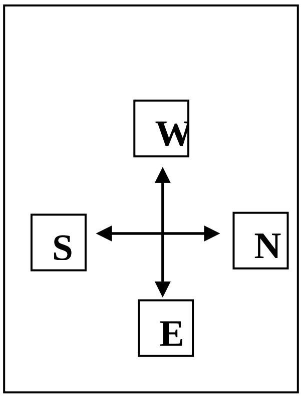


Fig .1. Layout of the experimental field

Legend



Replication
R_1=Replication 1
R_2= Replication 2
R_3=Replication 3

Treatments:
: Models

M_1= Model 1
M_2= Model 2
M_3= Model 3

3.7. Soil media preparation

Before starting the experiment the soil media for roof gardening was prepared using sandy loam soil: cow dung: coco dust: vermicompost= 50: 40: 4: 2 (weight basis). This soil media was used in three types of container like, Plastic box, plastic sac and multilayer plastic box. Before preparation of soil media, the soil and cow dung were spaded and larger clods were broken into fine pieces. After spaded all the stubbles and uprooted weeds were removed and then the soil and cow dung was made ready.

3.8 Manure and its method of application

Equal amount of cow dung and vermicompost mixture were used as top dressing after 2 month interval during the cropping season (1 year) as source of plant nutrition.

3.9 Sowing seeds and transplanting the seedlings

Healthy and uniform quality of seed and seedling were collected from BARI and sown / transplanted as per sowing/ planting schedule of concern vegetables during the July 2016 to June 2017.The spacing was maintained as per standard distance of concern vegetables. The seed/ seedlings were watered after sowing/ transplanting.

3.10 Roof Top Garden Calendar as Treatment wise

a) Model 1

Table 1: Sowing, planting and harvesting time in treatment wise Model-1

<table>
<tr><td>Treatment (Container)</td><td>July-Aug</td><td>Sep-Oct</td><td>Nov-Feb</td><td>Mar-Jun</td></tr>
<tr><td>T_1-Plastic box 1</td><td>Red amaranth</td><td colspan="2">Radish+ Brinjal</td><td>Gimakalmi + Cucumber</td></tr>
<tr><td>T_2-Plastic box 2</td><td>Gimakalmi</td><td colspan="2">Red amaranth + Cauliflower</td><td>Stem amaranth</td></tr>
<tr><td>T_3-Plastic box 3</td><td>Red amaranth</td><td colspan="2">Turnip + Tomato</td><td>Red amaranth + Okra</td></tr>
<tr><td>T_4-Plastic box 4</td><td>Red amaranth</td><td>Radish</td><td>Carrot</td><td>Indian spinach + Okra</td></tr>
<tr><td>T_5-Plastic box 5</td><td>Gimakalmi</td><td colspan="2">Bottle gourd + Spinach</td><td>Cucumber</td></tr>
<tr><td>T_6-Plastic box 6</td><td>Gimakalmi,</td><td colspan="2">Country bean + Spinach</td><td>Gimakalmi + Bitter gourd</td></tr>
<tr><td>T_7-Plastic box 7</td><td colspan="4">Year round Chilli + Coriander</td></tr>
<tr><td>T_8-Half drum</td><td colspan="4">Aroid (Kochu) + Gimakalmi</td></tr>
<tr><td>T_9-Sac</td><td>Red amaranth</td><td colspan="2">Lettuce + Bottle gourd leaf + Bunching onion</td><td>Indian spinach</td></tr>
</table>

b) Model 2

Table 2: Sowing, planting and harvesting time intreatment wise Model 2

Treatment (Container)	July-Aug	Sep-Oct	Nov-Feb	Mar-Jun
T_1-Plastic box 1	Red amaranth	Knolkhol+ Tomato		Gimakalmi + Okra
T_2-Plastic box 2	Red amaranth	Radish+ Brinjal		Red amaranth + Cucumber
T_3-Plastic box 3	Gimakalmi	Red amaranth+ Broccoli		Stem amaranth + Gimakalmi
T_4-Plastic box 4	Red amaranth	Capsicum	Carrot	Indian spinach + Okra
T_5-Plastic box 5	Gimakalmi	Bottle gourd +Spinach		Red amaranth + Yard long bean
T_6-Plastic box 6	Gimakalmi,	Country bean+ Red amaranth		Gimakalmi + Bitter gourd
T_7-Plastic box 7	Year round Chilli + Coriander+ Red amaranth			
T_8-Half drum	Aroid (Kochu) + Red amaranth+ Lettuce			
T_9-Multilayer box	Gimakalmi	Coriander+ Bottle gourd leaf + Red amaranth		Indian spinach

c) Model 3

Table 3: Sowing, planting and harvesting time in treatment wise Model -3

Treatment (Container)	July-Aug	Sep-Oct	Nov-Feb	Mar-Jun
T_1-Plastic box 1	Red amaranth	Turnip+ Brinjal		Gimakalmi + Okra
T_2-Plastic box 2	Red amaranth	Radish+ Tomato		Red amaranth + Cucumber
T_3-Plastic box 3	Gimakalmi	Red amaranth+ Broccoli		Stem amaranth + Gimakalmi
T_4-Plastic box 4	Red amaranth	Capsicum	Carrot	Okra
T_5-Plastic box 5	Gimakalmi	Country bean+ Spinach		Red amaranth + Yard long bean
T_6-Plastic box 6	Gimakalmi,	Bottle gourd+ Coriander		Gimakalmi + Indian spinach
T_7-Plastic box 7	Year round Chilli + Coriander+ Red amaranth			
T_8-Half drum	Aroid (Kochu) + Red amaranth			
T_9- Multilayer box	Gimakalmi	Lettuce+ Bottle gourd leaf + Red amaranth		Indian spinach

3.12 Intercultural operations

After sowing seeds and transplanting the seedlings, various kinds of intercultural operations were accomplished for better growth and development of the plants, which are as follows,

a) Gap filling

When the seedlings were well established, the soil around the base of each seedling was pulverized. A few gaps filling was done by healthy seedlings of the same stock where initial planted seedling failed to survive.

b) Weeding

Weeding was accomplished as and whenever necessary to keep the crop free from weeds, for better soil aeration and to break the crust.

c) Staking and Pruning

When the vine plants were well established, staking was given to each plant by bamboo sticks to keep them erect. Within a few days of staking, as the plants grew up, the plants were given a uniform moderate pruning.

d) Irrigation

Light irrigation was provided immediately after sowing seeds and transplanting the seedlings and it was continued till the seedlings established in the field. Thereafter irrigation was provided as per when needed.

3.13 Harvesting

Fruits and leafy vegetables were harvested following proper harvest index. Harvesting leafy vegetables was started from 05 August, 2016 and was continued up to 30 June 2017.

Table 3 : Sowing/Planting and harvesting time in Crop wise

Sl.#	Name of the crop	Sowing/Planting	Harvesting
1	Red amaranth	1 July, 2016	25 Aug, 2016
		3 Sept, 2016	27 Oct, 2016
		5 Mar, 2017	26 Apr,2017
2	Radish	3 Sept, 2016	28 Oct, 2016
3	Brinjal	1Nov, 2016	27 Feb, 2017
4	Gimakalmi	2 July, 2016	29 Aug, 2016
		1 Mar, 2017	30 Apr, 2017
5	Cucumber	1Mar, 2017	25 Jun, 2017
6	Cauliflower	2 Nov, 2016	26 Feb, 2016
7	Stem amaranth	2 Mar, 2017	28 Jun, 2017
8	Turnip	1 Sept, 2016	30 Oct, 2016
9	Tomato	1 Nov, 2016	27 Feb, 2017
10	Okra	1Mar, 2017	28 Jun, 2017
11	Carrot	1 Nov, 2016	27 Feb, 2017
12	Indian spinach	2 Mar, 2017	30 Jun, 2017
13	Bottle gourd	2 Sept, 2016	25 Dec, 2016
14	Spinach	1 Nov, 2016	27 Feb, 2017
15	Country bean	2Sept, 2016	25 Feb, 2017
16	Bitter gourd	1 Mar, 2017	30 Jun, 2017
17	Year round Chilli	15 Sept, 2016	30 Dec, 2016
18	Coriander	15 Nov, 2016	28 Feb, 2017
19	Aroid (Kochu)	10 Nov, 2016	27 Feb, 2017
20	Lettuce	1Sept, 2016	30 Oct, 2016
21	Bottle gourd leaf	10 Nov, 2016	28 Feb, 2017
22	Bunching onion	15 Mar, 2017	30 Jun, 2017

3.14 Data collection

Data on the yield parameters were recorded from the sample plants during the course of experiment.

3.14.1 Yield of vegetables per plant

An electric balance was used to measure the weight of fruits per plant. The total fruit yield of each plant measured separately during the harvest period and was expressed in gm.

3.14.2 Yield of vegetables per treatment

An electric balance was used to measure the weight of fruits per plot. The total fruit yield of each unit plot measured separately during the harvest period and was expressed in kilogram (kg).

3.15 Statistical analysis

The recorded data on different parameters were statistically analyzed by using MSTAT software to find out the significance of variation resulting from the experimental treatments. The mean values for all the treatments were accomplished by DMRT test. The significance of difference between pair of means was tested at 5% and 1% level of probability (Gomez and Gomez, 1984).


Plastic box


Preparation of plastic box


Half drum


Multilayer box


Preparation of multilayer box


Sac

Plate 1.Growing container for the rooftop garden

Plate 2. Sieving of soil and cowdung

Plate 3. Soil, cowdung, Cocodust& Vermicompost

Plate 4. Mixing of soil, cowdung, Cocodust& Vermicompost

Plate 5. Sowing of seeds in mixed media

Plate 6: Transplanting of seedling

Chapter IV: Results and Discussion

CHAPTER IV
RESULTS AND DISCUSSION

The present experiment was conducted to evaluation of vegetable production in rooftop gardening. Data on yield and price of vegetables were recorded to find out the suitable model for vegetables production on roof garden .The results have been presented, discussed and possible interpretations are given under the following headings:

4.1. Model 1

In model 1, Twenty two types of vegetables were produced in nine treatments during the time. The vegetables in nine treatments were T_1-Plastic box 1 (Red amaranth, Radish, Brinjal, Gimakalmi, Cucumber), T_2-Plastic box 2 (Gimakalmi, Cauliflower , Red amaranth, Stem amaranth), T_3-Plastic box 3 (Red amaranth, Turnip , Tomato, Red amaranth, Okra), T_4-Plastic box 4 (Red amaranth, Radish, Carrot, Indian spinach, Okra), T_5-Plastic box 5 (Gimakalmi, Bottle gourd, Spinach, Cucumber), T_6-Plastic box 6 (Gimakalmi, Country bean, Spinach, Bitter gourd, Gimakalmi), T_7-Plastic box 7 (Year round Chilli, Coriander), T_{8}-Half drum (Aroid (Kochu), Gimakalmi), T_9-Sac (Red amaranth, Lettuce, Bottle gourd leaf, Indian spinach, Bunching onion). In respect of yield (Fig. 2), the maximum yield was produced from the Treatment 3 (10.9 kg) followed by Treatment 5 (9.9 kg) and Treatment 6 (8.5 kg), while the lowest yield was found in Treatment 7 (3 kg). The low yield was produced from this treatment due to presence of less number of vegetables.

In terms of price (Fig. 3), the highest price was obtained by the Treatment 3 (413 tk) followed by Treatment 5 (313 tk), Treatment 6 (305 tk), while minimum was from Treatment 9 (128 tk) which was sac. The sac produced leafy type vegetables which prices were low compare to other vegetables.

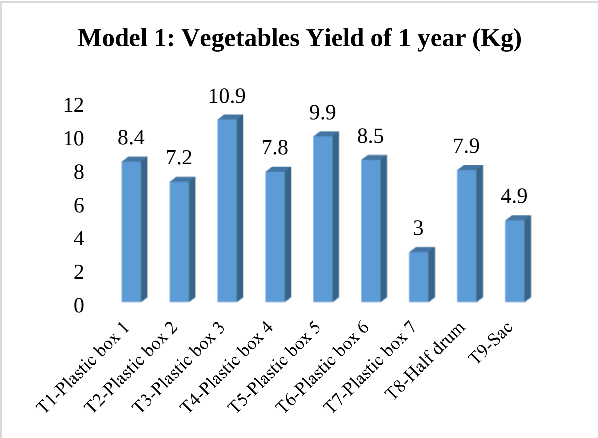


Fig 2. Vegetables yield (kg) from treatment9

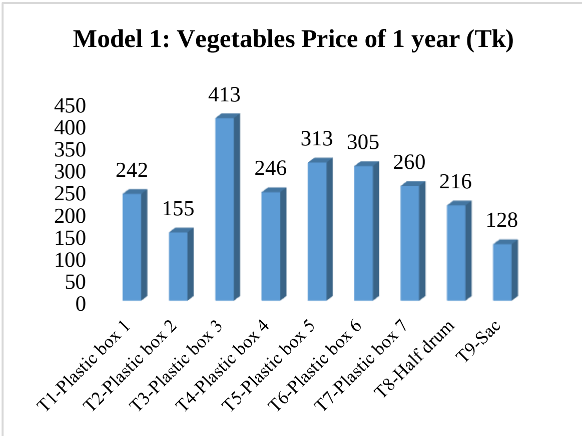
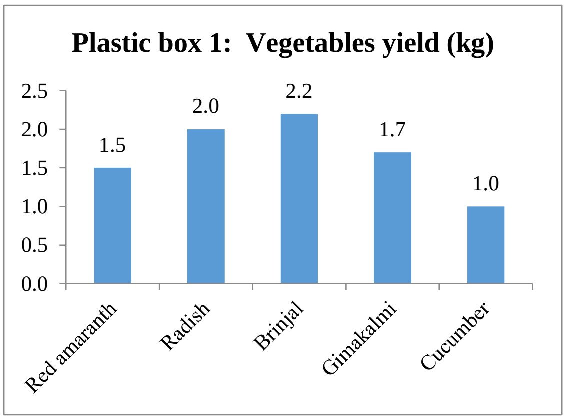


Fig 3. Vegetables Price(Tk) from treatment9

4.1. 1

T_1-Plastic box 1

The vegetables in 1st treatments (T_1-Plastic box 1) of model 1 were red amaranth, radish, brinjal, gimakalmi, cucumber. The yield of vegetables in this treatment was varied among the vegetable (Fig. 4). The highest yield was obtained in brinjal (2.2 kg) followed by radish (2.0 kg) and gima kalmi (1.7 kg), while lowest yield was obtained in cucumber (1.0kg).The production of cucumber was low due its infestation by fruit fly. In terms of vegetable price, highest price was obtained by brinjal (88 tk) followed by cucumber (50tk) in Fig.5. Though the production was the lowest in cucumber, but due to higher price of cucumber it got the second position in terms of price. The lowest price was obtained by red amaranth (30 tk).



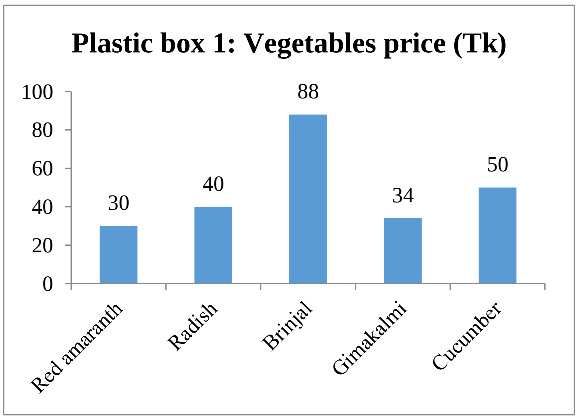


Fig 4. Vegetables yield (kg)from plastic box 1

Fig 5. Vegetables price(Tk) from plastic box 1

4.1. 2

T_2-Plastic box 2

The vegetables (T_2-Plastic box 2) of model 1 were gimakalmi, cauliflower, red amaranth, stem amaranth. There a variation of yield among the vegetables. The highest yield (Fig. 6) was obtained by the stem amaranth (2.8 kg) followed by gima kalmi (1.9 kg), while lowest yield was obtained by cauliflower (1.1kg).The low production of cauliflower was low due to only two cauliflower was produced in that plastic box. In terms of vegetable price,it was shown in Fig. 7,the highest price was obtained by stem amaranth (56 tk) followed by gima kalmi (38tk). The price of stem amaranth was higher (56 tk) due to its higher production (2.8 kg).

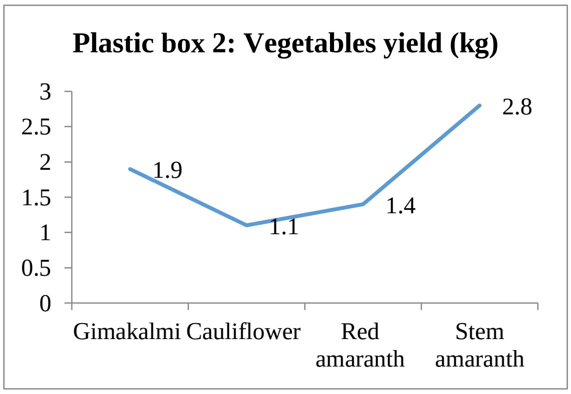


Fig 6. Vegetables yield(kg) from plastic box 2

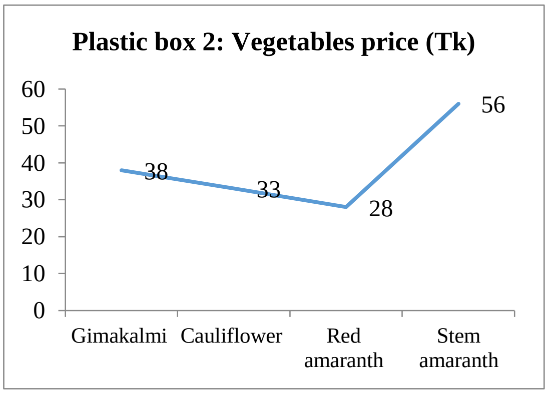
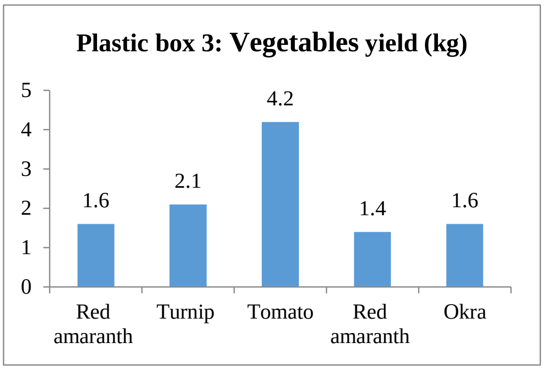


Fig 7. Vegetables price(Tk) from plastic box2

4.1. 3

T_3-Plastic box 3

The vegetables in 3rd treatments (T_3-Plastic box 3) of model 1 were red amaranth, turnip, tomato, red amaranth, okra. The yield of vegetables in this treatment was varied among the vegetables. The highest yield (Fig. 8) was produced in tomato (4.2 kg) followed by turnip (2.1 kg) and red amaranth, okra (1.6 kg), while lowest yield was obtained in red amaranth (1.4kg) when it was inter cropping with okra. The low production of red amaranth was the lowest due to its production was intercropping with okra. In terms of vegetable price was shown in Fig.9, the highest price was obtained by tomato (210 tk) followed by okra (80tk). The price of red amaranth was low (28 tk) due to its intercropping cultivation with okra.



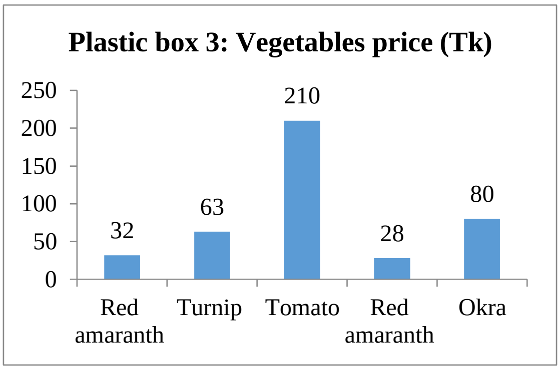


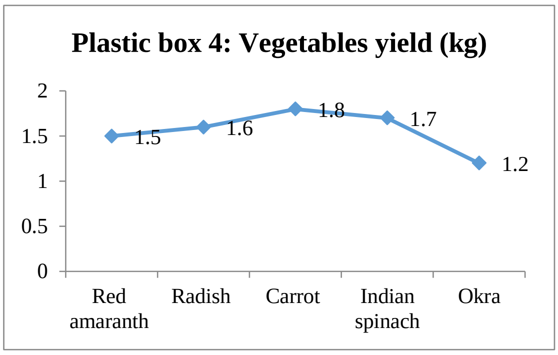
Fig 8. Vegetables yield (kg)from plastic box 3

Fig 9. Vegetables price(Tk) from plastic box3

4.1. 4

T_4-Plastic box 4

The vegetables in 4th treatments (T_4-Plastic box 4) of model 1 were red amaranth, radish, carrot, indian spinach, okra. There a variation of yield among the vegetables. It was shown in Fig. 10,the highest yield was obtained by the carrot (1.8 kg) followed by indian spinach (1.7 kg) and radish (1.6 kg), while the lowest yield was obtained by okra (1.2kg). The low production of okra was the lowest due to its production was intercropping with Indian spinach. In terms of vegetable price, it was shown in Fig.11 that the highest price was obtained by carrot (90 tk) followed by okra (60tk). The price of other vegetables viz., red amaranth, radish and Indian spinach were more or less same (30-34 tk).



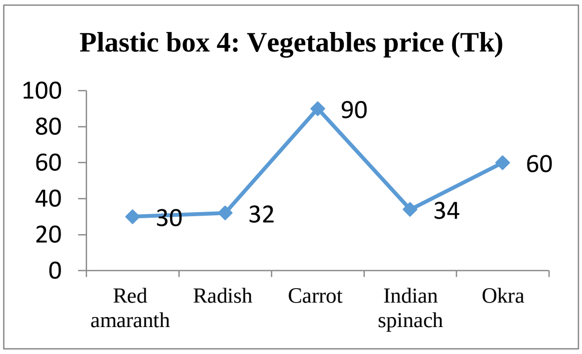


Fig 10. Vegetables yield (kg) from plastic box 4

Fig 11. Vegetables price (Tk.) from plastic box 4

4.1. 5

T_5-Plastic box 5

The yield of vegetables in 5th treatments (T_5-Plastic box 5) of model 1 was varied among the vegetables. The highest yield (Fig. 12) was produced by bottle gourd (5.2 kg) followed by gima kalmi and cucumber (1.6 kg), while the lowest yield was obtained by spinach (1.5kg). The higher production of bottle gourd was due to its bigger size of fruits. In terms of vegetable price, the highest price (Fig.13) was obtained by bottle gourd (156 tk) followed by cucumber (80tk). The price of gima kalmi was low (32 tk) due to its low production.

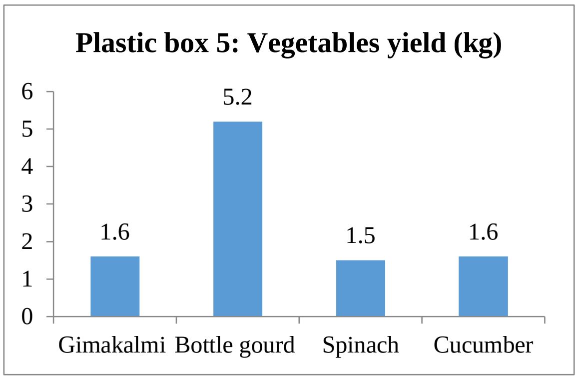


Fig 12. Vegetables yield(kg) from plastic box 5

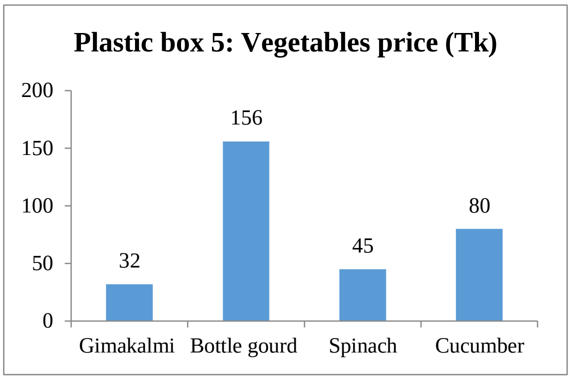
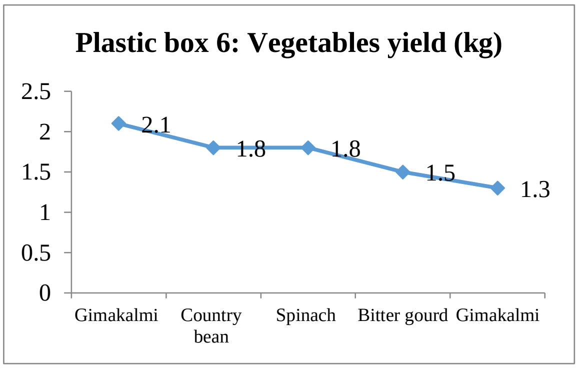


Fig 13. Vegetables price(Tk) from plastic box 5

4.1. 6

T_6-Plastic box 6

There was a variation of yield among the vegetables of 6th treatments (T_6-Plastic box 6) of model 1. The highest yield (Fig.14) was obtained by the gima kalmi (2.1kg) followed by country bean and spinach (1.8 kg), while lowest yield was obtained by bitter gourd (1.5kg). The production of bitter gourd was low due its fruit fly infestation. The vegetable price was shown in Fig.15, the highest price was obtained by country bean (108 tk) followed by bitter gourd (75tk). The price of gima kalmi was low (26 tk) because it was inter cropping cultivated with bitter gourd.



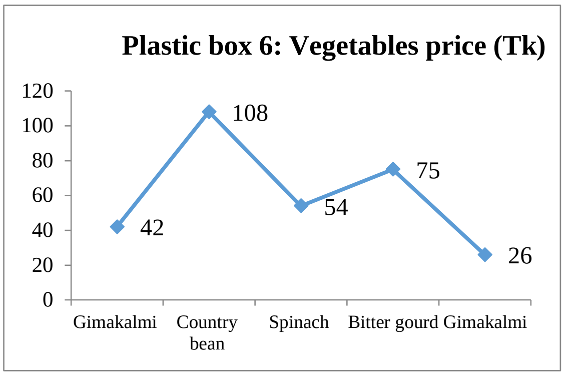


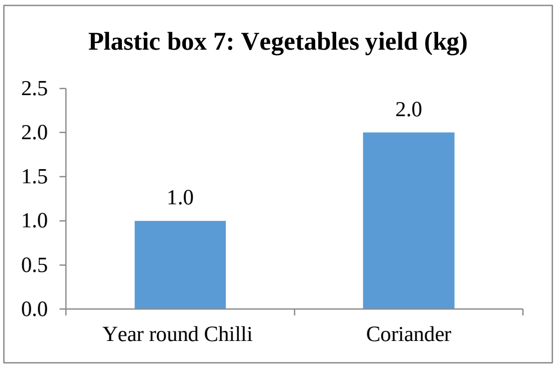
Fig 14. Vegetables yield (kg) from plastic box 6

Fig 15. Vegetables price (Tk) from plastic box 6

4.1. 7

T$_7$-Plastic box 7

The vegetables in 7th treatments (T$_7$-Plastic box 7) of model 1 were year round chilli, coriander. The yield of vegetables in this treatment was varied among the vegetables. It was shown in Fig. 16,the highest yield was produced by coriander (2.0 kg) followed by year round chilli (1.0 kg). The highest price was obtained by coriander (160 tk) followed by year round chilli (100tk) (Fig.17).



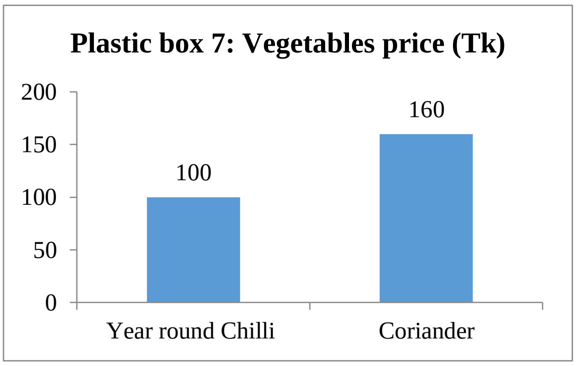


Fig 16. Vegetables yield (kg) from plastic box 7

Fig 17. Vegetables price (Tk) from plastic box 7

4.1. 8

T_8-Half drum

The yield of vegetables in 8th treatments (T_8- Half drum) of model 1 was varied among the vegetables. The highest yield was produced by aroid (5.8 kg) followed by gima kalmi (2.1kg) (Fig. 18). In terms of vegetable price, the highest price was obtained by aroid (174 tk) followed by gima kalmi (42tk) (Fig. 19).

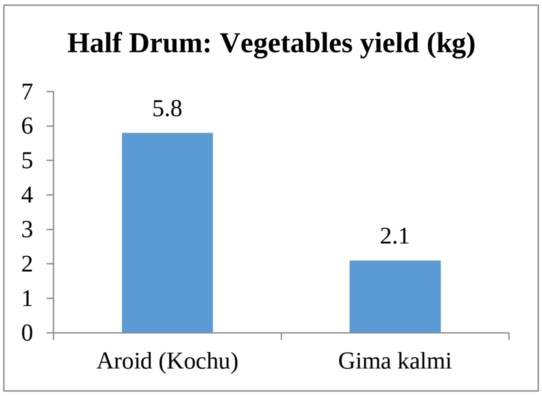


Fig 18. Vegetables yield (kg) from half drum

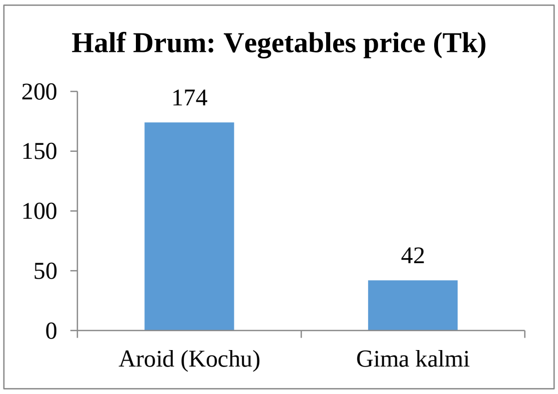
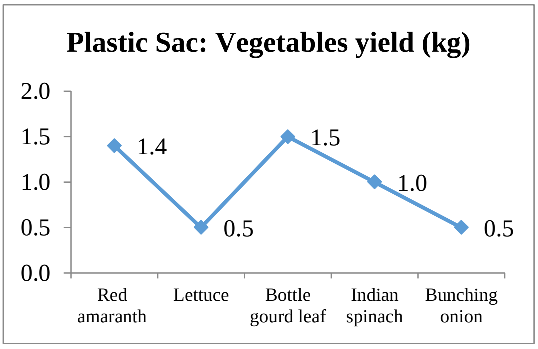


Fig 19. Vegetables price (Tk) from half drum

4.1. 9

T_9-Sac

The vegetables in 9th treatments (T_9- Sac) of model 1 were red amaranth, lettuce, bottle gourd leaf, indian spinach, bunching onion. The yield of vegetables in this treatment was varied among the vegetables. The highest yield was produced by bottle gourd leaf (1.5 kg) followed by red amaranth (1.4kg) and indian spinach (1.0 kg). Lowest production was produced by lettuce and bunching onion (0.5 kg) (Fig. 20). The highest and lowest price was obtained by bottle gourd leaf (30 tk) and indian spinach (20 tk) (Fig. 21). But there were no significant difference among the price of five vegetables.



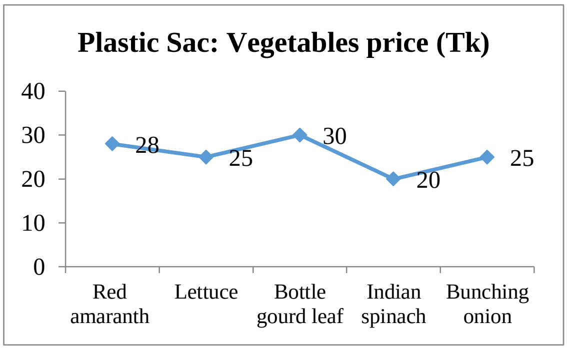


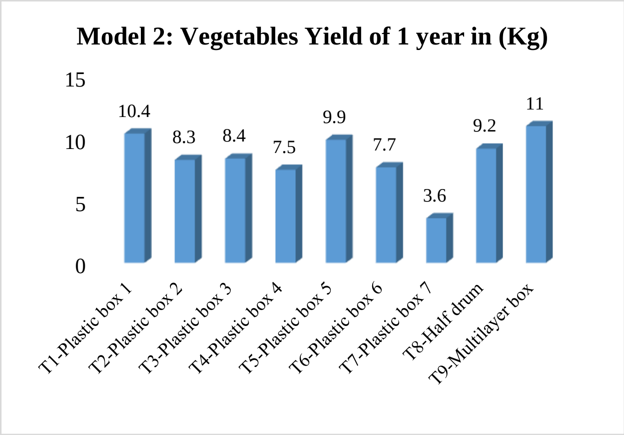
Fig 20. Vegetables yield(kg) from plastic sac

Fig 21. Vegetables price(Tk) from plastic sac

4.2. Model 2

Twenty two types of vegetables were produced in nine treatments in model 2 during the time. The vegetables in nine treatments were T_1-Plastic box 1 (Red amaranth, Knolkhol, Tomato, Gimakalmi, Okra), T_2-Plastic box 2 (Red amaranth, Radish, Brinjal, Red amaranth, Cucumber), T_3-Plastic box 3 (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi), T_4-Plastic box 4 (Red amaranth, Capsicum, Carrot, Indian spinach, Okra), T_5-Plastic box 5 (Gimakalmi, Bottle gourd, Spinach, Red amaranth, Yard long bean), T_6-Plastic box 6 (Gimakalmi, Country bean, Red amaranth, Bitter gourd, Gimakalmi), T_7-Plastic box 7 (Year round Chilli, Red amaranth, Coriander), T_8-Half drum (Aroid (Kochu), Red amaranth, Lettuce), T_9-Multilayer box (Coriander, Gimakalmi, Indian spinach, Bottle gourd leaf, Red amaranth). In respect of yield, it was shown in Fig. 22,the maximum yield was produced from the Treatment 9 (11.7 kg) followed by Treatment1 (10.4 kg) and Treatment 5 (9.9 kg), while the lowest yield was by Treatment 7 (3.6 kg).

In terms of price, the highest price was obtained by the Treatment 1 (396tk) followed by Treatment 9 (310tk), while minimum was from Treatment 3 (190tk) which was Plastic box 3 (Fig. 23). The treatment 3 mainly produced leafy type vegetables (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi) which prices were low compare to other vegetables.



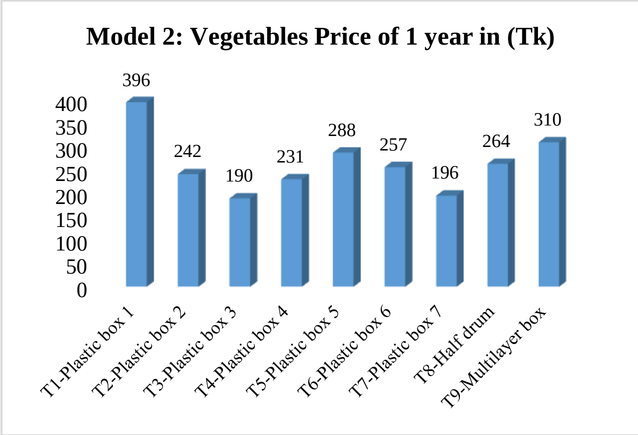


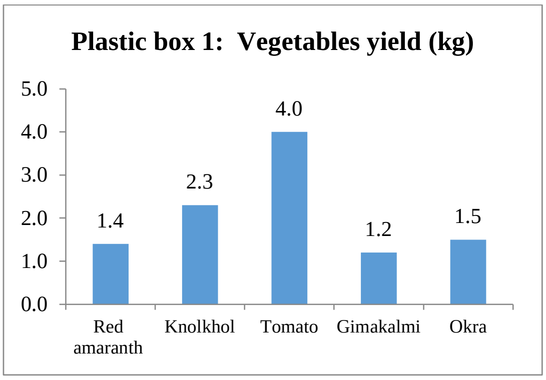
Fig 22. Vegetables yield (kg)from treatment 9

Fig 23. Vegetables Price(Tk.) from treatment 9

4.2.1

T_1-Plastic box 1

The yield of vegetables in 1st treatments (T_1-Plastic box 1) of model 2 was varied among the vegetables. The highest yield was obtained by tomato (4.0 kg) followed by knolkhol (2.3 kg), while lowest yield was obtained in gima kalmi (1.2kg) (Fig. 24).The production of gima kalmi was the lowest due to it was cultivated as intercrop with okra. In terms of vegetable price, the highest price was obtained by tomato (200 tk) followed by okra (75tk) (Fig. 25). The production and price (24 tk) were low in gima kalmi due to it was cultivated as intercropping method.



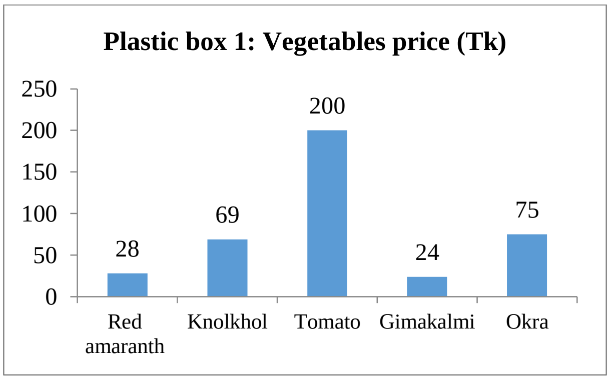


Fig 24. Vegetables yield (kg)from plastic box 1

Fig 25. Vegetables price(Tk) from plastic box 1

4.2.2

T_2-Plastic box 2

The vegetables in 2nd treatments (T_2-Plastic box 2) of model 2 were red amaranth, radish, brinjal, red amaranth, cucumber. There a variation of yield among the vegetables.The highest yield was obtained by the brinjal (2.3 kg) followed by radish (2.0 kg), while lowest yield was obtained by cucumber (1.0kg) (Fig. 26).The production of cucumber was low due it was infested by fruit fly. In terms of vegetable price, the highest price was also obtained by brinjal (92 tk) followed by cucumber (50tk) (Fig. 27). The price of other three vegetables was more or less same (28 to 40 tk).

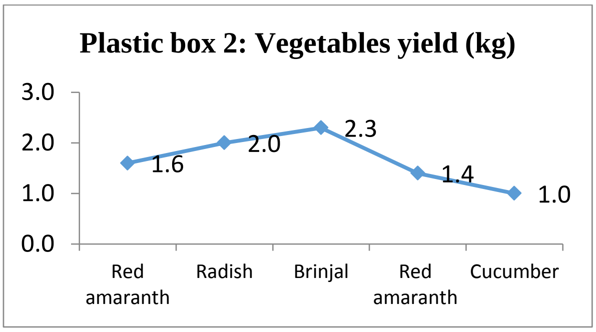


Fig 26. Vegetables yield (kg)from plastic box 2

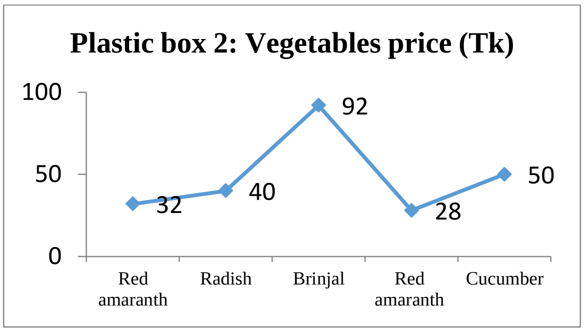


Fig 27. Vegetables price (Tk)from plastic box2

4.2.3

T_3-Plastic box 3

The yield of vegetables in 3rd treatments (T_3-Plastic box 3) of model 2 was varied among the vegetables. The highest yield was produced in stem amaranth (2.8 kg) followed by gimakalmi (1.9 kg), while lowest yield was obtained in broccoli (1.1kg) (Fig. 28), though least three vegetables yield was more or less same (1.1 to 1.4 kg). The production of broccoli was the lowest due to its weight was light. In terms of vegetable price, the highest price was obtained by stem amaranth (56 tk) followed by broccoli (44tk) (Fig. 29). The price of Gimakalmi (IC) was low (24 tk) due to it was intercropping with stem amaranth.

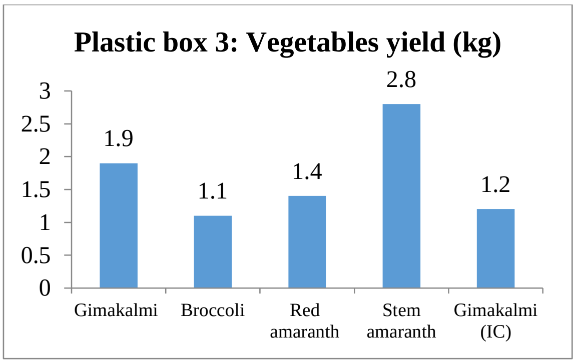


Fig 28. Vegetables yield (kg) from plastic box 3

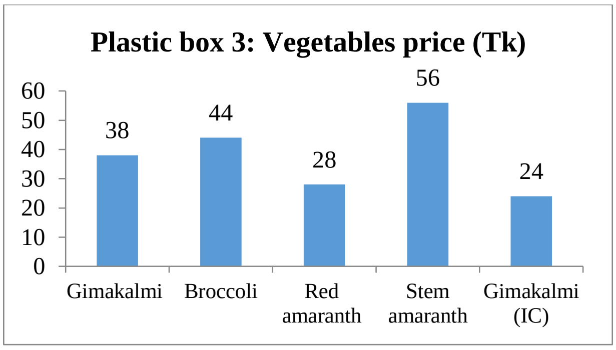


Fig 29. Vegetables price (Tk) from plastic box3

4.2.4

T_4-Plastic box 4

The vegetables in 4th treatments (T_4-Plastic box 4) of model 2 were red amaranth, capsicum, carrot, indian spinach, okra. There a variation of yield among the vegetables. Though the highest yield was obtained by the carrot (1.8 kg) followed by Indian spinach (1.7 kg) (Fig. 30) but first four vegetables production was near about same (1.5 to 1.8 kg), while lowest yield was obtained by okra (0.9kg). The low production of okra was the lowest due to its production was intercropping with indian spinach. In terms of vegetable price, the highest price was obtained by carrot (90 tk) followed by okra (45tk) (Fig. 31). The price of other vegetables viz., red amaranth, capsicum and indian spinach were more or less same (30-34 tk).

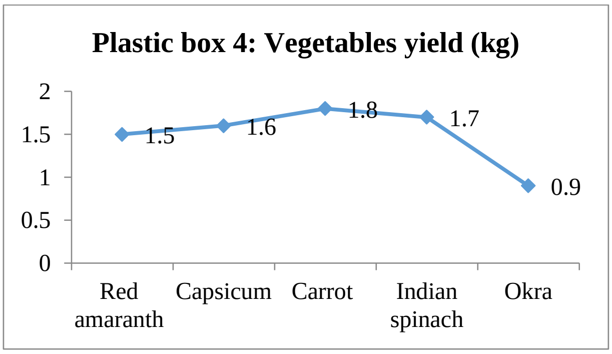


Fig 30. Vegetables yield (kg)from plastic box 4

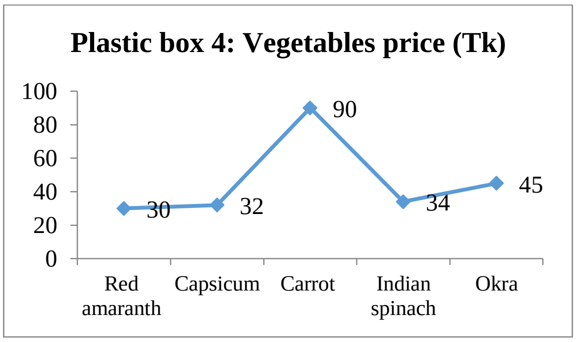


Fig 31. Vegetables price(Tk) from plastic box4

4.2.5

T_5-Plastic box 5

The vegetables in 5th treatments (T_5-Plastic box 5) of model 2 were gimakalmi, bottle gourd, spinach, red amaranth, yard long bean. The yield of vegetables in this treatment was varied among the vegetables. The highest yield was produced by bottle gourd (4.5 kg) followed by yard long bean (1.7 kg), while the lowest yield was obtained by red amaranth (1.0kg) (Fig. 32). The higher production of bottle gourd was the highest due to its bigger size of fruits. In terms of vegetable price, the maximum price was obtained by bottle gourd (135 tk) followed by yard long bean (78tk) (Fig. 33). The price of red amaranth was low (20 tk) due to it was cultivated with yard long bean as intercropping method.

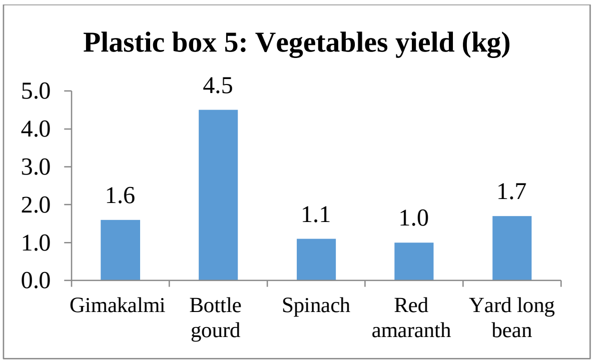


Fig 32. Vegetables yield(kg) from plastic box 5

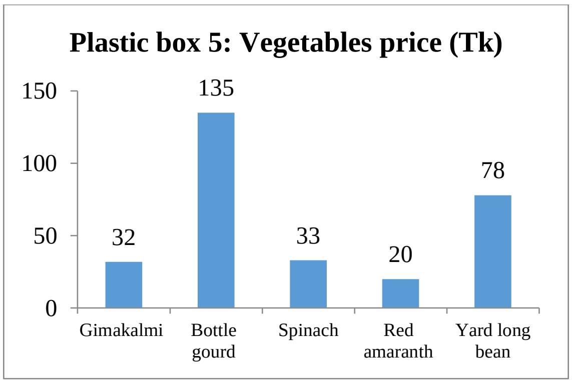


Fig 33. Vegetables price(Tk) from plastic box 5

4.2.6

T_6-Plastic box 6

The vegetables in 6th treatments (T_6-Plastic box 6) of model 2 were gimakalmi, country bean, red amaranth, bitter gourd, gimakalmi. There a variation of yield among the vegetables. The highest yield was obtained by the gima kalmi (2.0kg) followed by country bean (1.9 kg) and red amaranth (1.5 kg), while the lowest yield was obtained by bitter gourd (0.9kg) (Fig. 34). The production of bitter gourd was the lowest due to its fruit fly infestation. In terms of vegetable price, the highest price was obtained by country bean (114 tk) followed by bitter gourd (45tk) (Fig. 35). The price of gima kalmi (IC) was low (28 tk) because it was cultivated with bitter gourd as inter cropping method.

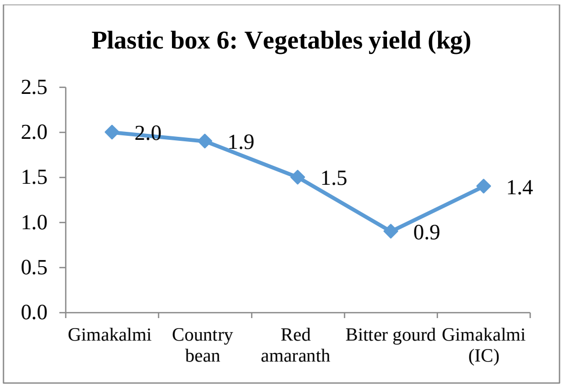


Fig 34. Vegetables yield(kg) from plastic box 6

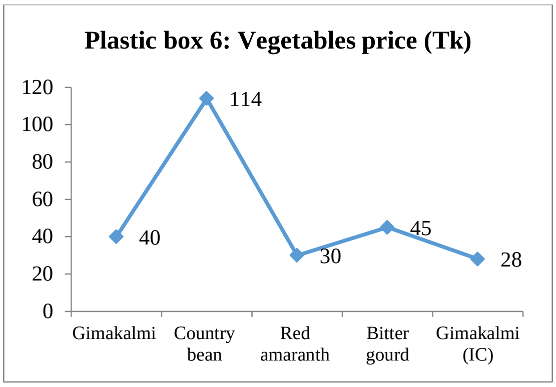


Fig 35. Vegetables price(Tk) from plastic box 6

4.2.7

T_7-Plastic box 7

The yield of vegetables in 7th treatments (T_7-Plastic box 7) of model 2 was varied among the vegetables. The highest yield was produced by red amaranth (1.8 kg) followed by coriander (1.0 kg), while the lowest production produced by year round chilli (0.8 kg) (Fig. 36). In terms of vegetable price, the highest price was obtained by year round chilli, coriander (80 tk) followed by red amaranth (36tk) (Fig. 37).

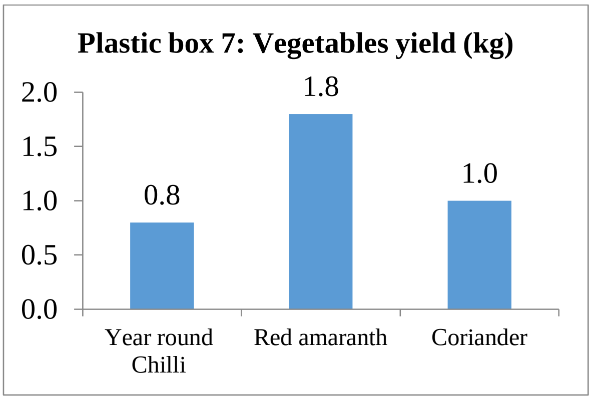


Fig 36. Vegetables yield(kg) from plastic box 7

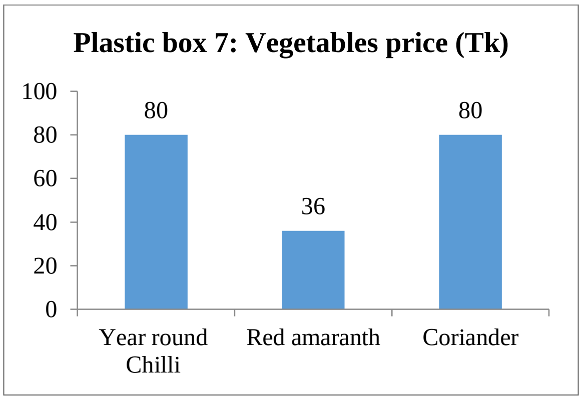


Fig 37. Vegetables price(Tk) from plastic box 7

4.2.8

T_8-Half drum

The yield of vegetables in 8th treatments (T_8- Half drum) of model 2 was varied among the vegetables. The highest yield was produced by aroid (6.5 kg) followed byred amaranth (2.2kg), while lowest production was produced by lettuce (0.5 kg) (Fig. 38). In terms of vegetable price, the highest price was obtained by aroid (195 tk) followed by red amaranth (44tk) (Fig. 39).

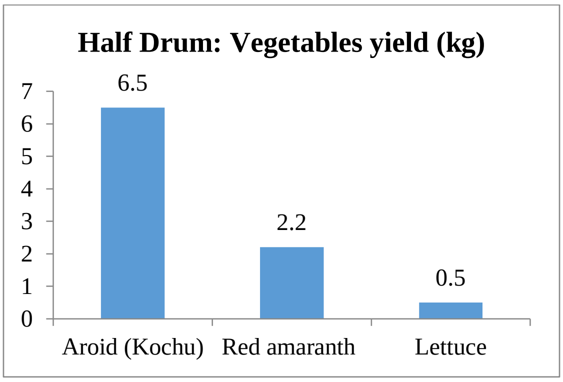


Fig 38. Vegetables yield(kg) from half drum

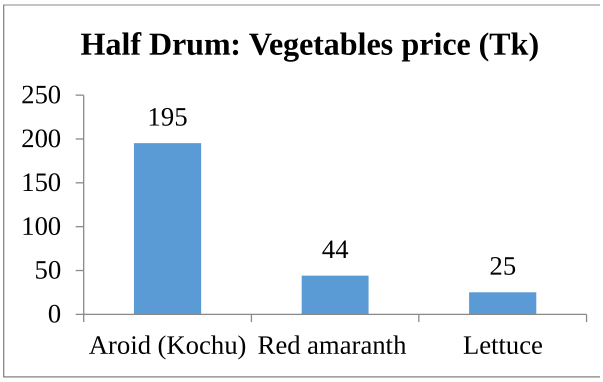


Fig 39. Vegetables price(Tk) from half drum

4.2.9

T_9-Multilayer box

The yield of vegetables in 9th treatments (T_9- Multilayer box) of model 2 was varied among the vegetables. The highest yield was produced by gimakalmi (3.5 kg) followed by Indian spinach (2.5kg) and bottle gourd leaf (2.1 kg). The lowest production was produced by red amaranth (1.4 kg) (Fig. 40). In terms of vegetable price, the highest was obtained by coriander (120 tk) followed by Gimakalmi (70tk) (Fig. 41). But there were no significant difference among the price of rest three vegetables (indian spinach, bottle gourd leaf, red amaranth).

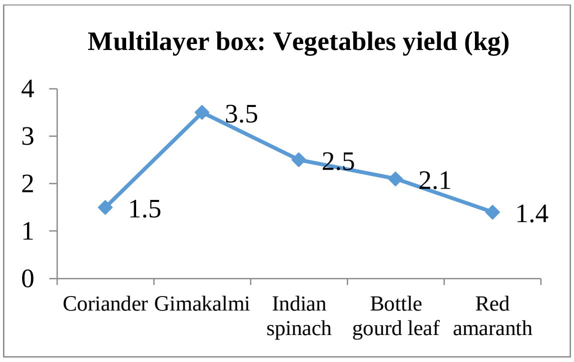


Fig 40. Vegetables yield (kg)\from Multilayer box

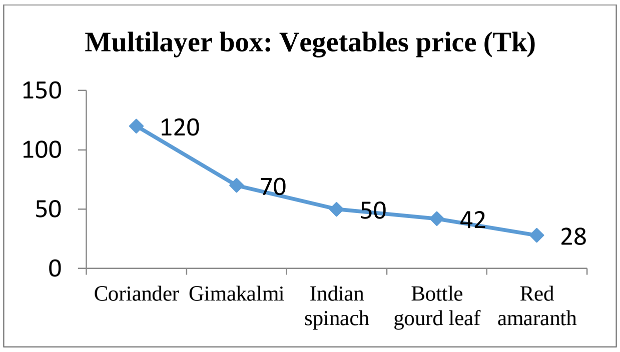


Fig 41. Vegetables price (Tk) from Multilayer box

4.3. Model 3

In model 3, also twenty two types of vegetables were produced in nine treatments during the season. The vegetables in nine treatments were T_1-Plastic box 1 (Red amaranth, Turnip, Brinjal, Gimakalmi, Okra), T_2-Plastic box 2 (Red amaranth, Radish, Tomato, Red amaranth, Cucumber), T_3-Plastic box 3 (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi), T_4-Plastic box 4 (Red amaranth, Carrot, Capsicum, Okra), T_5-Plastic box 5 (Gimakalmi, Country bean, Spinach, Red amaranth, Yard long bean), T_6-Plastic box 6 (Gimakalmi, Bottle gourd, Coriander, Indian spinach, Gimakalmi), T_7-Plastic box 7 (Year round Chilli, Coriander, Red amaranth), T_8-Half drum (Aroid (Kochu), Red amaranth), T_9-Multilayer box (Lettuce, Gimakalmi, Indian spinach, Bottle gourd leaf, Red amaranth). In respect of yield, it was shown Fig.42, the maximum yield was produced from the Treatment 6 (9.5 kg) followed by Treatment 9 (8.9 kg) and Treatment 2 (8.2 kg) and Treatment 8 (8.2), while the lowest yield was by Treatment 7 (3.2 kg) which was similar to other two models.

In terms of price,it was shown Fig.43, the highest price was obtained by the Treatment 1 (295tk) followed by Treatment 5 (264tk) and Treatment 6 (262 tk), while minimum was from Treatment 3 (180tk) which was Plastic box 3. This treatment mainly produced leafy type vegetables (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi), which prices were low compare to other vegetables.

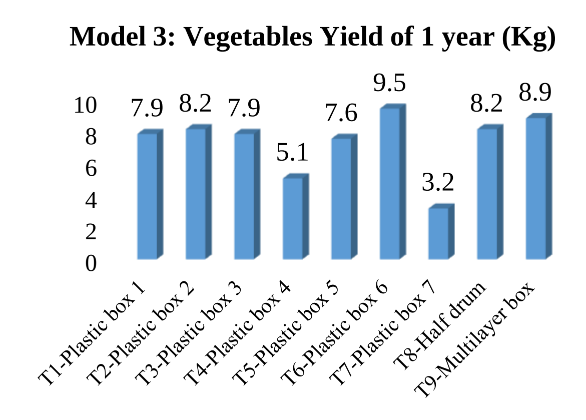


Fig 42. Vegetables yield(Kg) from 9 treatments

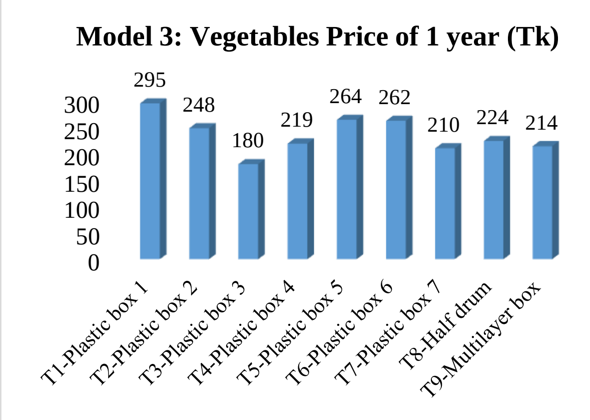


Fig 43. Vegetables price(Tk.) from 9 treatments

4.3.1

T_1-Plastic box 1

The yield of vegetables in 1st treatments (T_1-Plastic box 1) of model 3 was varied among the vegetables. The highest yield was obtained in brinjal (2.4 kg) followed by turnip (2.0 kg) and okra (1.5 kg) (Fig.44), while lowest yield was obtained in gima kalmi (0.9kg). The low production of gima kalmi was the lowest due to it was produced in intercropping with okra. In terms of vegetable price, the highest price was obtained by brinjal (120 tk) followed by okra (75tk) and turnip (60 tk) (Fig.45). The price of rest two vegetables (red amaranth and gima kalmi) was more or less same (18 to 22 tk).

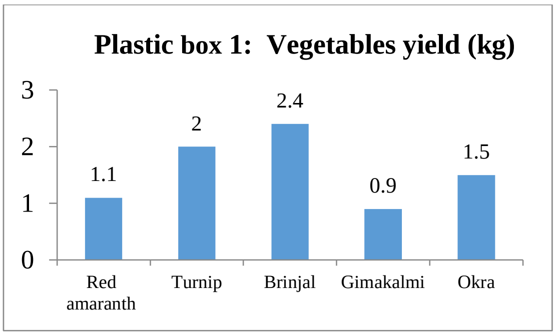


Fig 44. Vegetables yield(kg) from plastic box 1

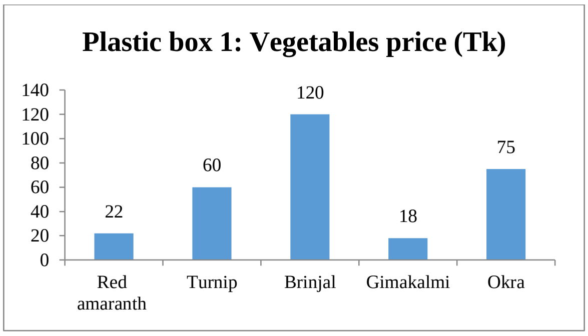


Fig 45. Vegetables price(Tk) from plastic box 1

4.3.2:

T_2-Plastic box 2

The vegetables in 2nd treatments (T_2-Plastic box 2) of model 3 were red amaranth, radish, tomato, red amaranth, cucumber. There a variation of yield among the vegetables. The highest yield was obtained by the tomato (3.0 kg) followed by radish (1.8 kg), while lowest yield was obtained by cucumber (0.8kg) (Fig.46). The production of cucumber was the lowest due to its infestation by fruit fly. In terms of vegetable price, the highest price was obtained by tomato (120 tk) followed by cucumber (40tk) (Fig.47), though the production of cucumber was lowest among the vegetables. The price of other vegetables was more or less same in this treatment (24 to 36 tk).

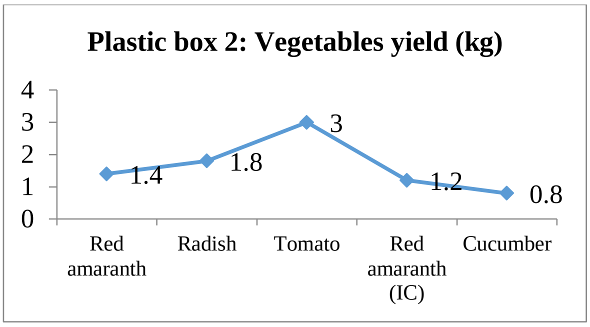


Fig 46. Vegetables yield(kg) from plastic box 2

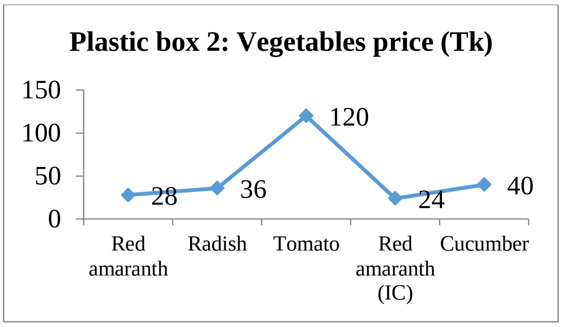


Fig 47. Vegetables price(Tk) from plastic box2

4.3.3

T_3-Plastic box 3

The vegetables in 3rd treatments (T_3-Plastic box 3) of model 3 were gimakalmi, broccoli, red amaranth, stem amaranth, gimakalmi. The yield of vegetables in this treatment was varied among the vegetables. The highest yield was produced in stem amaranth (2.4 kg) followed by gima kalmi (1.6 kg) and red amaranth (1.5 kg), while the lowest yield was obtained in broccoli (1.1kg) (Fig.48). The yield of broccoli was lowest because this vegetable is light in nature. In terms of vegetable price, there was no significant change among the vegetables studied. The range of price was 26 to 48 tk only (Fig.49).

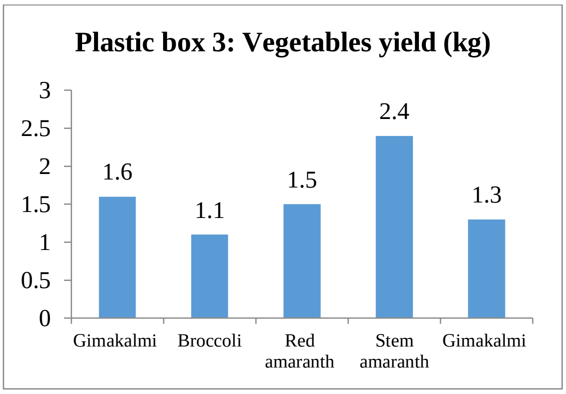


Fig 48. Vegetables yield(kg) from plastic box 3

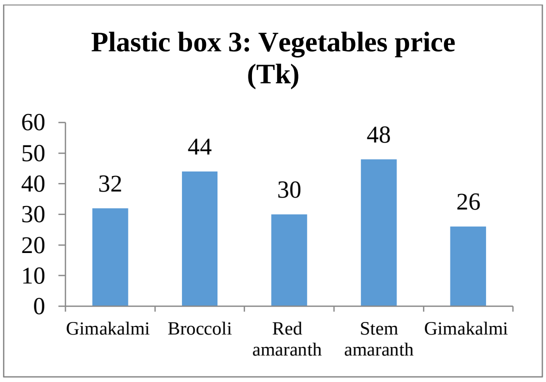


Fig 49. Vegetables price (Tk)from plastic box3

4.3.4

T_4-Plastic box 4

The vegetables in 4th treatments (T_4-Plastic box 4) of model 3 were red amaranth, carrot, capsicum, okra. There a variation of yield among the vegetables. The highest yield was obtained by the carrot (1.7 kg) followed by red amaranth and okra (1.2 kg)

(Fig.50), while lowest yield was obtained by capsicum (1.0kg). The production of capsicum was the lowest due to its production was very much sensitive to pest and diseases. In terms of vegetable price, the highest price was obtained by carrot (85 tk) followed by okra (60tk), while minimum price was obtained by red amaranth (24 tk) (Fig.51).

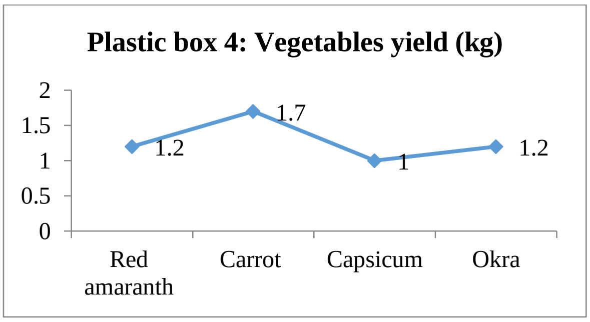


Fig 50. Vegetables yield(kg) from plastic box 4

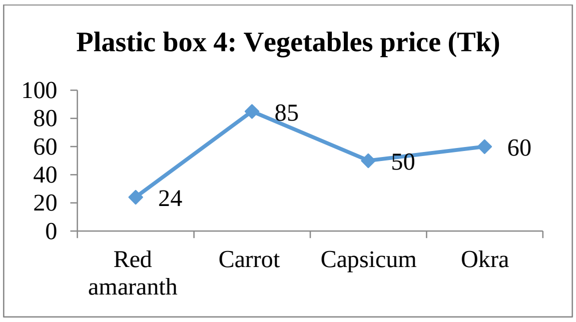


Fig 51. Vegetables price(Tk) from plastic box4

4.3.5

T_5-Plastic box 5

The yield of vegetables in 5th treatments (T_5-Plastic box 5) of model 3 was varied among the vegetables. The highest yield was produced by spinach (2.0 kg) followed by country bean (1.6 kg) (Fig.52), while the yield of other three vegetables (viz., gimakalmi, red amaranth, yard long bean) were near about same (1.2 to 1.4 kg). In terms of vegetable price, highest price was obtained by country bean (96 tk) followed by spinach (60tk) and yard long bean (56 tk) (Fig.53). The price of red amaranth and gima kalmi was low (24 to 28 tk) due to its low production.

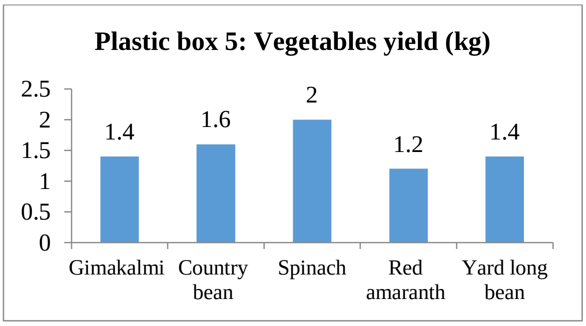


Fig 52. Vegetables yield (kg)from plastic box 5

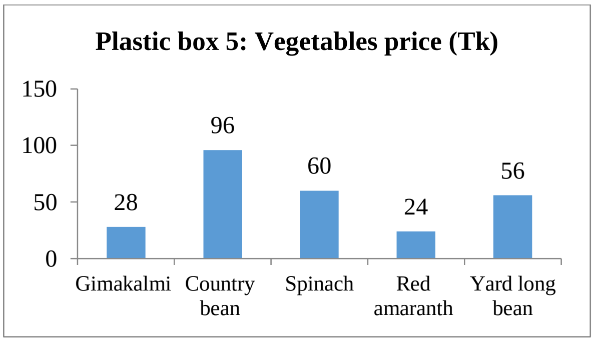


Fig 53. Vegetables price(Tk) from plastic box 5

4.3.6

T_6-Plastic box 6

The vegetables in 6th treatments (T_6-Plastic box 6) of model 3 were gima kalmi, bottle gourd, coriander, indian spinach, Gimakalmi (IC). There a variation of yield among the vegetables. The highest yield was obtained by the bottle gourd (3.9kg) (Fig.54). The yield of other four vegetables [viz., gima kalmi, coriander, indian spinach, Gimakalmi (IC)] was more or less same (1.1 to 1.7kg) because of all the vegetables were leafy in nature. In terms of vegetable price, the highest price was obtained by bottle gourd (117 tk) followed by coriander (55tk) (Fig.55). The price of other three vegetables [viz., gima kalmi, indian spinach, Gimakalmi (IC)] was more or less same (24 to 32tk).

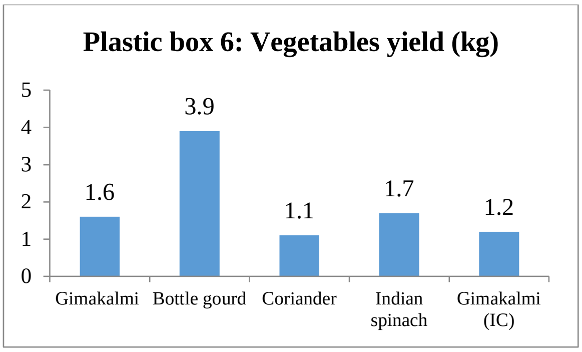


Fig 54. Vegetables yield(kg) from plastic box 6

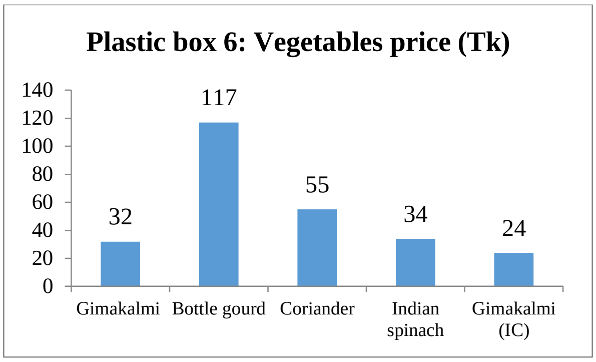


Fig 55. Vegetables price(Tk) from plastic box 6

4.3.7

T_7-Plastic box 7

The yield of vegetables in 7th treatments (T_7-Plastic box 7) of model 3 was varied among the vegetables. The highest yield was produced by coriander (1.5 kg) followed by red amaranth (1.0 kg) (Fig.56), while lowest yield was produced by year round chilli (1.0 kg). In terms of vegetable price, the highest price was obtained by coriander (120 tk) followed by year round chilli (70tk) (Fig.57), while lowest price was obtained by red amaranth (20 tk).

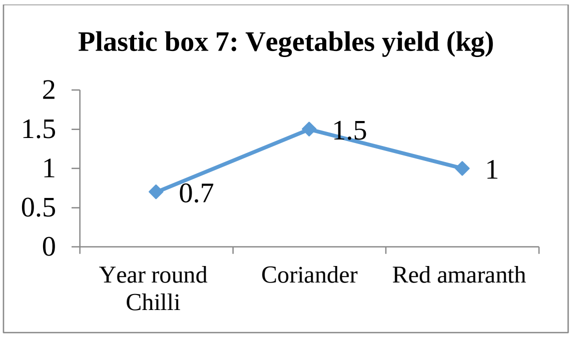


Fig 56. Vegetables yield(kg) from plastic box 7

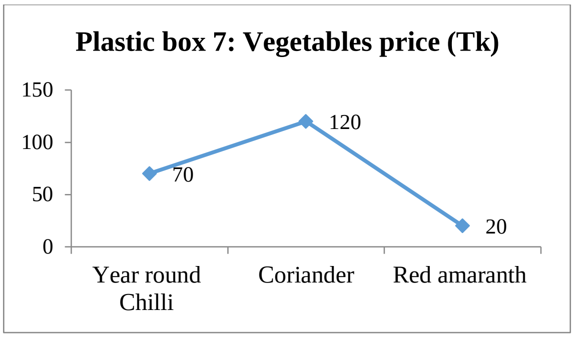


Fig 57. Vegetables price(Tk) from plastic box 7

4.3.8

T_8-Half drum

The yield of vegetables in 8th treatments (T_8- Half drum) of model 3 was varied among the vegetables. The highest yield was produced by aroid (6.0 kg) followed by red amaranth (2.2kg) (Fig.58). The production of red amaranth was low because of at the later stage of the year red amaranth could not grow due to vigorous growth of aroid. In terms of vegetable price, the highest price was also obtained by aroid (180 tk) followed by red amaranth (44tk) (Fig.59).

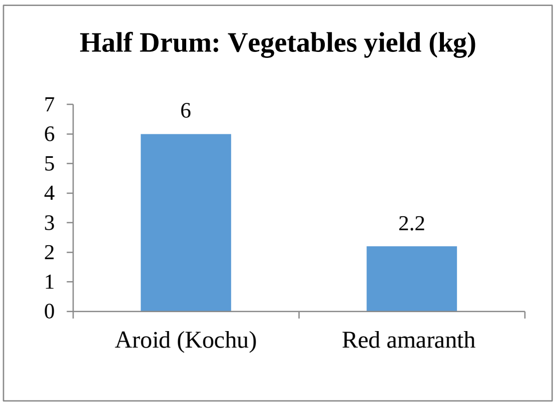


Fig 58. Vegetables yield(kg) from half drum

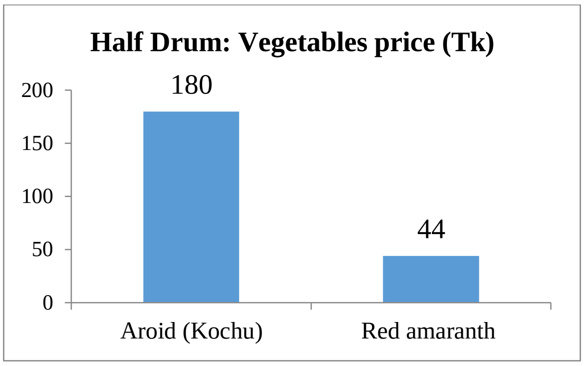


Fig 59. Vegetables price(Tk) from half drum

4.3.9.

T_9-Multilayer box

The yield of vegetables in 9th treatments (T_9- Multilayer box) of model 3 was varied among the vegetables. The highest yield was produced by gima kalmi (2.5 kg) followed by indian spinach (2.2kg) and bottle gourd leaf (1.8 kg) (Fig.60). Lowest production was produced by lettuce (1.2 kg). In terms of vegetable price, the highest price was obtained by lettuce (60 tk) followed by gima kalmi (50tk) (Fig.61). The price of rest three vegetables (viz., indian spinach, bottle gourd leaf, red amaranth) was 24 to44 tk.

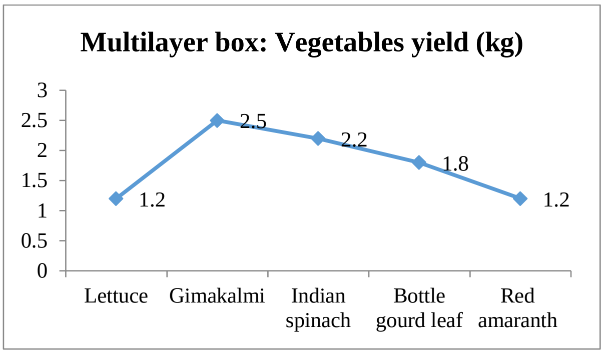


Fig 60. Vegetables yield(kg) from Multilayer box

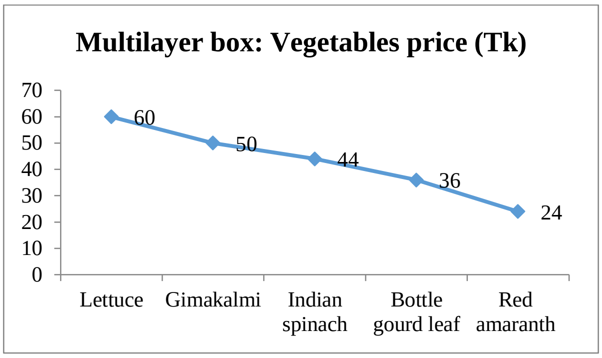


Fig 61. Vegetables price(Tk) from Multilayer box

4.4. Comparison of Model -3

In terms of vegetables yield during one year from a 100 sqft area, It was shown in Fig.62; Model 2 produced the maximum yield (76 kg) followed by Model 1 (68.5 kg), while lowest by Model 3 (66.5 kg). The yield variation was very narrow due to maximum vegetables were same in among 3 model, while only 2-3 vegetables were differed.

In terms of vegetable price, it was shown in Fig.63; Model 2 obtained the maximum (2374 tk) followed by Model 1 (2278 tk), while minimum was from Model 3 (2116 tk).

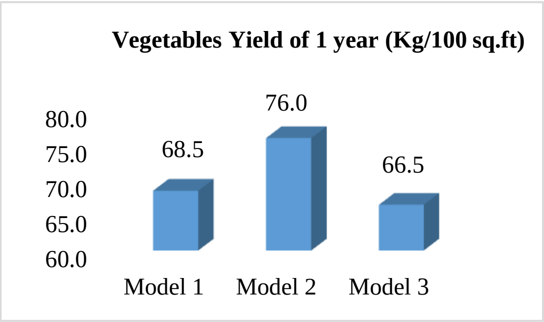


Fig 62.Vegetables yield (Kg) from Model- 3

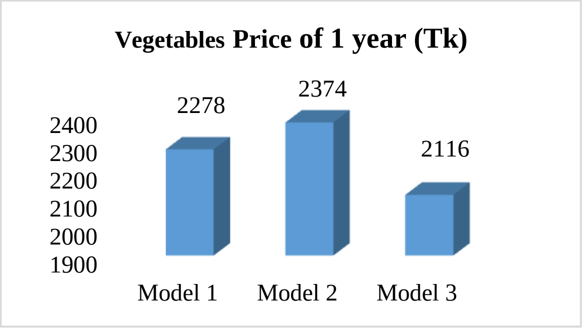


Fig 63.Vegetables price (Tk) from Model-3

Chapter V: Summary and Conclusion

CHAPTER V

SUMMARY AND CONCLUSION

Summary

The experiment was conducted at roof top of Mushroom laboratory, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur during July 2016 to June 2017. The experiment was laid out in Completely Randomized Design (CRD) having three replications. The treatment of this experiment were T_1= Plastic box 1, T_2= Plastic box 2, T_3= Plastic box 3, T_4= Plastic box 4, T_5= Plastic box 5, T_6= Plastic box 6, T_7= Plastic box 7, T_8= Half drum, T_9= Sac/ Multilayer box and three roof top garden models viz., Model 1, Model 2, Model 3 included in the study. Each model consists of 22 type vegetables. Considering the 3 models, there were a narrow difference in terms of vegetable yield and prices. The experiment was conducted in a 100 sqft area on roof top to ensure regular and proper nutrition to a family.

Performance of model 1: Twenty two types of vegetables were produced in nine treatments during the season. The vegetables in nine treatments were T_1-Plastic box 1 (Red amaranth, Radish, Brinjal, Gimakalmi, Cucumber), T_2-Plastic box 2 (Gimakalmi, Cauliflower , Red amaranth, Stem amaranth), T_3-Plastic box 3 (Red amaranth, Turnip , Tomato, Red amaranth, Okra), T_4-Plastic box 4 (Red amaranth, Radish, Carrot, Indian spinach, Okra), T_5-Plastic box 5 (Gimakalmi, Bottle gourd, Spinach, Cucumber), T_6-Plastic box 6 (Gimakalmi, Country bean, Spinach, Bitter gourd, Gimakalmi), T_7-Plastic box 7 (Year round Chilli, Coriander), T_8-Half drum (Aroid (Kochu), Gimakalmi), T_9-Sac (Red amaranth, Lettuce, Bottle gourd leaf, Indian spinach, Bunching onion). In respect of yield maximum yield was produced from the Treatment 3 (10.9 kg) followed by Treatment 5 (9.9 kg) and Treatment 6 (8.5 kg), while the lowest yield was by Treatment 7 (3 kg). The low yield was produced from this treatment due presence of less number of vegetables. In terms of price, the highest price was obtained by the Treatment 3 (413 tk) followed by Treatment 5 (313 tk), Treatment 6 (305 tk), while minimum was from Treatment 9 (128 tk) which was sac. The sac mainly produced leafy type vegetables which prices were low compare to other vegetables.

Performance of model 2: Twenty two types of vegetables were produced in nine treatments during the season. The vegetables in nine treatments were T_1-Plastic box 1

(Red amaranth, Knolkhol, Tomato, Gimakalmi, Okra), T_2-Plastic box 2 (Red amaranth, Radish, Brinjal, Red amaranth, Cucumber), T_3-Plastic box 3 (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi), T_4-Plastic box 4 (Red amaranth, Capsicum, Carrot, Indian spinach, Okra), T_5-Plastic box 5 (Gimakalmi, Bottle gourd, Spinach, Red amaranth, Yard long bean), T_6-Plastic box 6 (Gimakalmi, Country bean, Red amaranth, Bitter gourd, Gimakalmi), T_7-Plastic box 7 (Year round Chilli, Red amaranth, Coriander), T_8-Half drum (Aroid (Kochu), Red amaranth, Lettuce), T_9-Multilayer box (Coriander, Gimakalmi, Indian spinach, Bottle gourd leaf, Red amaranth). In respect of yield maximum yield was produced from the Treatment 9 (11.7 kg) followed by Treatment1 (10.4 kg) and Treatment 5 (9.9 kg), while the lowest yield was by Treatment 7 (3.6 kg). In terms of price, the highest price was obtained by the Treatment 1 (396tk) followed by Treatment 9 (310tk), while minimum was from Treatment 3 (190tk) which was Plastic box 3. The treatment 3 mainly produced leafy type vegetables (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi) which prices were low compare to other vegetables.

Performance of model 3: In this model twenty two types of vegetables were produced in nine treatments during the season. The vegetables in nine treatments were T_1-Plastic box 1 (Red amaranth, Turnip, Brinjal, Gimakalmi, Okra), T_2-Plastic box 2 (Red amaranth, Radish, Tomato, Red amaranth, Cucumber), T_3-Plastic box 3 (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi), T_4-Plastic box 4 (Red amaranth, Carrot, Capsicum, Okra), T_5-Plastic box 5 (Gimakalmi, Country bean, Spinach, Red amaranth, Yard long bean), T_6-Plastic box 6 (Gimakalmi, Bottle gourd, Coriander, Indian Spinach, Gimakalmi), T_7-Plastic box 7 (Year round Chilli, Coriander, Red amaranth), T_8-Half drum (Aroid (Kochu), Red amaranth), T_9-Multilayer box (Lettuce, Gimakalmi, Indian spinach, Bottle gourd leaf, Red amaranth). In respect of yield maximum yield was produced from the Treatment 6 (9.5 kg) followed by Treatment 9 (8.9 kg), Treatment 2 (8.2 kg) and Treatment 8(8.2), while thelowest yield was by Treatment 7 (3.2 kg) which was similar to other two models. In terms of price, the highest price was obtained by the Treatment 1 (295tk) followed by Treatment 5 (264tk) and Treatment 6 (262 tk), while minimum was from Treatment 3 (180tk) which was Plastic box 3. This treatment mainly produced leafy type vegetables (Gimakalmi, Broccoli, Red amaranth, Stem amaranth, Gimakalmi), which prices were low compare to other vegetables.

Conclusion and Recommendation:

Considering the above result of this experiment the following conclusions and recommendation can be drawn:

Conclusions

1. In terms of vegetables yield during one year from a 100 sqft area, Model 2 produced the maximum yield (76 kg) followed by Model 1 (68.5 kg), while the lowest by Model 3 (66.5 kg).
2. In terms of vegetable price, Model 2 obtained the maximum (2374 tk) followed by Model 1 (2278 tk), while minimum was from Model 3 (2116 tk).

Recommendations

The present study revealed that, on a roof garden from a 100 sqft area, anybody can follow any model preferably Model 2 and Model 1, which vegetable price (2374 tk, 2278 tk, respectively) and yield (76 kg, 68.5 kg, respectively) were higher. This study was just 1-year result, so after another year trial it may be concluded which model is best in terms of yield and price.

Therefore it can be suggest that Model 2 and Model 1may be popularized by roof top gardening which will ensure regular and proper nutrition to a family from a 100 sqft area.

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Appendices

APPENDICES

Appendix 1.

Monthly mean temperature and relative humidity during the crop period

Year	Month	Temperature (^0C)		Relative humidity (%)	
		Maximum	Minimum	Average	Rainfall (mm)
2016	July	31.6	25.70	80.45	687.80
	August	32.30	26.70	74.95	299.00
	September	32.00	26.40	75.50	145.80
	October	32.10	23.50	38.85	393.30
	November	29.40	19.5	37.30	63.0
	December	26.00	13.80	62.10	0.0
2017	January	24.60	13.40	64.75	91.40
	February	25.9	14.50	61.10	67.80
	March	31.10	20.70	65.20	20.00
	April	34.00	23.90	60.55	19.80
	May	33.80	24.30	64.30	312.40
	June	31.4	25.8	77.00	391.40

Appendix 2.

Chemical properties of the experimental soil

P^H	OM	Ca	Mg	K	Total N	P	S	B	Zn	Fe	Zn
	(%)	Meq/100g			(%)	µg/g					
6.0	0.70	0.65	0.55	0.14	0.028	8	10	0.1	0.1	80	4.0
Critical level		2.0	0.8	0.20	0.12	14	14	0.2	2.0	10	5.0

Appendix 3.

Crop Calendar of Roof Top Gardening

Crop Calendar of Roof Top Gardening														
Sl. No	Name of the crops	Sowing/ Planting times in a year	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1	Red amaranth	1												
		2												
		3												
2	Radish	1												
3	Brinjal	1												
4	Gimakalmi	1												
		2												
5	Cucumber	1												
6	Cauliflower	1												
7	Stem amaranth	1												
8	Turnip	1												
9	Tomato	1												
10	Okra	1												
11	Carrot	1												
12	Indian spinach	1												
13	Bottle gourd	1												
14	Spinach	1												
15	Country bean	1												
16	Bitter gourd	1												
17	Year round Chilli	1												
18	Coriander	1												
19	Aroid (Kochu)	1												
20	Lettuce	1												
21	Bottle gourd leaf	1												
22	Bunching onion	1												

Notes: Sowing/Planting time   Harvesting time   **Overlaping Between sowing/Panting & Harvesting time**