EFFECT OF VERMICOMPOST AND GIBBERELLIN ON BITTER GOURD PRODUCTION IN THE WATER SURFACE OF FISH POND

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CERTIFICATE

This is to certify that the thesis entitled ***"EFFECT OF VERMICOMPOST AND GIBBERELLIN ON BITTER GOURD PRODUCTION IN THE WATER SURFACE OF FISH POND"*** *submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTERS OF SCIENCE (M.S.)*** *in* ***HORTICULTURE****, embodies the result of a piece of bonafide research work carried out by* ***SOURAV MODAK****, Registration No. 12-5102 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

Dated:

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DEDICATED

TO

MY BELOVED PARENTS

ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	Milliliter
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celsius
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Milligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Liter
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

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The Author

LIST OF CONTENTS

LIST OF CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

LIST OF APPENDICES

EFFECT OF VERMICOMPOST AND GIBBERELLIN ON BITTER GOURD PRODUCTION IN THE WATER SURFACE OF FISH POND

ABSTRACT

A field experiment was conducted to determine the effect of vermicompost and gibberellin on bitter gourd production in the water surface of fish pond during March to June 2019 at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka. The experiment was considered of two factors. Factor A: vermicompost (3 levels) *viz*. (i) 90% coco peat + 10% broken bricks (V_0), (ii) 30% vermicompost + 60% coco peat/pot + 10% broken bricks (V_1) and (iii) 60% vermicompost + 30% coco peat/pot + 10% broken bricks (V_2) and Factor B: GA_3 (2 levels) *viz*. (i) 0 ppm GA_3 (Control) (G_0) and (ii) 40 ppm GA_3 (G_1). It was laid out in the two factors completely randomized design (CRD) with three replications. Regarding vermicompost, V_2 showed higher growth and yield and resulted highest fruit yield (21.58 t ha^{-1}) compared to control (11.97 t ha^{-1}). In terms of GA_3 application, the highest fruit yield (19.35 t ha^{-1}) was found from G_1 (40 ppm GA_3) whereas the lowest (14.62 t ha^{-1}) was from control treatment G_0 (0 ppm GA_3). Considering interaction effect, V_2G_1 showed highest fruit weight pot^{-1} (1783 g) and fruit yield (24.76 t ha^{-1}) whereas the lowest fruit weight pot^{-1} (945.60 g) and fruit yield (10.80 t ha^{-1}) were obtained from V_0G_0. It can be concluded that vermicompost with GA3 application was effective for better gourd cultivation in floating agriculture.

CHAPTER I

INTRODUCTION

Bitter gourd or balsam pear (*Momordicacharantia* L.) belongs to the family Cucurbitaceae, is one of the popular and commercially important cucurbitaceous vegetable crops extensively grown throughout the country for its nutritive value and medicinal properties. The fruits are prepared for consumption in many ways and are quite commonly used as fried, boiled, and stuffed forms. It is a highly cross-pollinated crop and it is a climbing vine in nature. It ranks first among the cucurbits in respect of iron and vitamin C content (AVRDC, 2005).

Though Bangladesh is an agricultural country, it has a serious deficiency in vegetables and the scarcity is much more dominant during summer. Bitter gourd can play an important role to elevate vegetable consumption in the summer season. The annual production of vegetables is only 4.31 million tons including potato but we need around 11.15 million tons (Anon, 2002).

The main problem of bitter gourd production is the male and female flower ratio. The number of male flowers is more than female flowers due to high temperature and high humidity (Baset *et al.*, 2014). Pollen viability is lost relatively rapidly. The stigma is usually receptive for 1 day before or after flower opening, after which it dries and turns brown. The plant growth regulators (PGR's) are considered as a new generation agrochemical after fertilizers, pesticides, and herbicides. In bitter gourd, it is possible to increase the yield by increasing the fruit set by using growth regulators. The use of PGR's like GA_3 has an ability to modify the plant growth, sex ratios and yield contributing characters, while micronutrients like boron will be a useful alternative to increase crop production (Shantappa*et al.*, 2007). Growth regulators are known to have an effect on the production of the earliest flower, yield (Gedam *et al.*, 1998), the ratio of male/female flower

(Bisaria, 1974), number of fruits, the weight of fruit (Gopalkrishman and Choudhury, 1978). Exogenous application of growth regulators has shifted the sex expression towards femaleness by increasing the production of the female flowers and suppressing the male flowers in bitter gourd (Parkash, 1974).

Organic farming is a crop production system, which favors maximum use of organic matter, keeps the environment healthy, and discourages synthetically generated agro-inputs used for maintaining soil fertility and productivity and controlling insect-pests under conditions of sustainable natural resources (Rana, 2004). In today's era, heavy doses of chemical fertilizers and pesticides are being used by the farmers to get a better yield of various field crops. These chemical fertilizers and pesticides decreased soil fertility and caused health problems for the consumers. Due to the adverse effects of chemical fertilizers, interest has been stimulated for the use of organic manures (Follet *et al*., 1981and John and Prabha, 2013).

Vermicomposting is a promising method of transforming unwanted and virtually supplies of organic wastes into usable substrates. Bevacqua and Mellano (1993 and Hammad *et al*., 2011) reported that compost-treated soils had lower pHs and increased levels of organic matter, primary nutrients, and soluble salts. Vermicomposts are products that are derived from the accelerated biological degradation of organic wastes by earthworms and microorganisms. Vermicomposts are finely divided peat-like materials with high porosity, aeration, drainage, water-holding capacity (Edwards and Burrows, 1988 and Sangeeta *et al*., 2018). They have greatly increased surface areas, providing more microsites for microbial decomposing organisms, and strong adsorption and retention of nutrients (Shi-wei and Fu-zhen, 1991 and Das *et al*., 2015). Among various sources of organic manures, vermicompost has been recognized as having considerable potential as soil amendments. The vermicompost has been found to

be an ideal organic source of nutrients as, it is rich in macro and micronutrients and helps to increase yield (Hidalgo, 1999, Meena *et al.*, 2007).

Generally, the floating agricultural practices production system is yearly generating vegetables and species for local communities. In summer, vegetables such as bitter gourd, okra, ribbed gourd, Indian spinach, brinjal, cucumber, red amaranths, stem amaranths, wax gourd, etc. are cultivated in floating beds. In Bangladesh, the main crop is rice and is cultivated all year round and this crop is occupying most of the cultivable land. As a result, the vegetable production area is decreasing day by day. So, floating agriculture can be an alternative way to increase vegetable production and the area of cultivation. Besides, fish culture is a major source of income.

Again, the present study was conducted in pond water surface and itself also is a source of plant nutrients. Excreta of fishes and different feeds that are given to fishes are decomposed and are treated as plant nutrients. Broken bricks which were used in the pot for the support of bitter gourd plant were also a source of plant nutrient like ammonia (NH_3), where ammonia is converted into Nitrate (NO_3). These nutrients are involved in the growth and development of the bitter gourd plants. Fish pond constituents of Phosphate. Hence, plants can get Phosphate from the fish ponds.

However, very limited research was done regarding floating agriculture using vermicompost and GA_3. Therefore, the present study was designed to evaluate the response of vermicompost and GA_3 for bitter gourd production on pond water. Considering the above facts, the present experiment has been undertaken with the following objectives:

1. To utilize the surface of the fish pond and nutrients obtained from fish culture for the cultivation of bitter gourd.

2. To evaluate the effect of vermicompost in the surface of the pond water for bitter gourd production
3. To find out the effect of GA_3 in pond water for bitter gourd cultivation
4. To assess the combined effect of vermicompost and GA_3 for bitter gourd cultivation in pond water

CHAPTER II

REVIEW OF LITERATURE

The literature about the response of vermicompost and gibberellin of bitter gourd on pond water is presented in this chapter. However, relative information on the effect of vermicompost and GA_3 on bitter gourd is not adequate, analogies from other crops have also been included to emphasize a certain point of view.

Literature related to the present study has been reviewed below.

2.1 Effect of vermicompost

Sureshkumar *et al.* (2019) investigated the effect of organic nutrients on certain growth and yield characters of bitter gourd (*Momordica charantia* L.) ecotype Mithipagal through organic nutrient management practices. The experiment consisted of 13 treatments replicated thrice. Results of the experiment revealed that the application of vermicompost @ 5t ha^{-1} and seaweed extract 3% along with Azospirillum @ 2 kg ha^{-1} improved the growth, yield, and quality performance of bitter gourd ecotype "Mithipagal". Among the treatments, T_5 (vermicompost 5t + seaweed extract 3% + azospirillum 2 kg ha^{-1}) selected the highest in growth parameters *viz.*, vine length, number of primary branches, number of leaves per plant. It was closely followed by T_2 (vermicompost 5t + humic acid 2% + Azospirillum 2 kg ha^{-1}). Regarding yield characteristics, fruit weight, fruit yield per plant (36.39 kg), and fruit yield per ha (2.92 t). And it was followed by T_2 which registered the yield per plant (35.35 kg) and fruit yield per ha (2.72t).

Gajjela *et al.* (2018) stated that among the cucurbits, bitter gourd has got important nutritional and medicinal properties. The juice of bitter gourd is a remedy for diabetic patients. Traditional organic bitter gourd cultivation involves the use of farmyard manure, vermicompost, and poultry manure which do not have the

required yield potential whereas by foliar spray of liquid organic manures like panchagavya, vermiwash, jeevamrit, humic acid, etc has important plant nutrients which are required for their growth and productivity. These liquid organic manures are cheap, as they are prepared by the farmers themselves on their farm and they are easy to prepare and apply. These liquid manures not only increase yield but also improve quality and post-harvest shelf life of produce and maintain soil health and sustainability in the long run.

Shree *et al*. (2018) experimented to evaluate the effect of different combinations of organic (vermicompost) and inorganic (NPK) sources of nutrients on growth, yield, and quality of bitter gourd. The application of vermicompost @ 4.68 t ha^{-1} recorded 3.99 kg/fruits per vine with an average fruit weight of 62.18 g/fruit. Application of NPK @ 100:60:50 kg ha^{-1} recorded maximum fruit yield/vine (3.64 kg) and with average fruit weight 56.75 g/fruit. Interaction effect of vermicompost @4.68 t ha^{-1} and inorganic fertilizer, NPK @ 50:30:25 kg ha^{-1} was found to be the best treatment combination for yield and yield attributing traits and as well as for benefit-cost ratios. The maximum yield i.e. 36.81 t ha^{-1} was found under the combined use of vermicompost@ 4.68 t ha^{-1} and inorganic fertilizer@ 50:30:25 kg ha^{-1}. It was also observed that some of the quality attributes like TSS (o Brix), Zn, and Fe content of the fruit were significantly influenced with the application of different levels of vermicompost while vitamin C and Fe were significantly affected with the application of both organic and inorganic fertilizers in different combinations.

Sundararasu (2017) studied an experiment on the effect of vermicompost and vermiwash on growth and yield of bottle gourd, (*Lagenaria siceraria*). In this present study analysis of soil nutrients after cultivation was high in the experimental plots which indicate that the presence of micronutrients in vermicompost and vermiwash. Increased application of the vermicompost and vermiwash quantity resulted in increased soil copper and iron content due to

increased organic inputs which resulted in improved soil aeration and microbial activity. In the present investigation, the yield of bottle gourd in response to vermicompost 50%: vermiwash 50% was highly significant in experimental plot II which may due to the increased availability of more exchangeable nutrients in the soil by the application of vermicompost and vermiwash.

Sundararasu (2017) carried out the work to evaluate the impact of vermicompost and vermiwash on the growth and yield of bottle gourd plants. Available nutrients of the soil both in control and experimental plots were studied and interrupted results. Plant growth, number of leaves per plant, number of flowers, and fruits were recorded. Vermicompost and vermiwash treated soil showed increased plant growth, several leaves, flowers, and fruits compared to control soil. A significant yield was recorded on the vermicompost and vermiwash added field. The present study suggested that both vermicompost and vermiwash were favorable vigorous yields of bottle gourd.

Nagar *et al.* (2017) studied an experiment on the effect of organic manures and different levels of NPK on growth and yield of bottle gourd. The application of vermicompost (5.0 t ha^{-1}). Recorded length of the main vine (4.09), number of primary branches per vine (11.85), length of leaf 65 days after sowing (27.35 cm), percent fruit set (55.61), number of fruit per vine (9.8), length of fruit (40.48 cm), the girth of fruit (24.96 cm), the weight of fruit (954.30 g), yield per vine (8.99), yield (242.70 q ha^{-1}). These findings indicated that vermicompost played a significant role in enhancing the growth of bottle gourd.

Thriveni *et al.* (2015) studied an experiment on the effect of inorganic, organic fertilizers, and biofertilizers on growth, flowering, yield, and quality attributes of bitter gourd. Even though the crop was affected by 'Philine' the average number of fruits per plant varied significantly between 17.3 in absolute control to 40 in T10. Similarly, the length of fruit varied between 12 to 17 cm, girth between 11.9

to 13.6 cm, and unit fruit between 42.4 and 86.4 g. All these parameters positively increased with incremental uses of inorganic nutrients and further with integrated uses of vermicompost either alone or with biofertilizers. Integration of vermicompost application @ 2.5 tons/ha increased the fruit yield by 6.4, 5.2, and 4.6 percent compared to respective yields due to 50, 75 and 100 percent recommended doses of fertilizers respectively.

Namayandeh and Shirdareh (2015) conducted an experiment on The Effect of Compost, Vermicompost, and Urea fertilizers on Operation and Operation Fracture on Pumpkin Msmayy (*Cucurbita pepo* L.). The results of this experiment showed that the effect of vermicompost and compost has been more than urea in making the number of female flowers in Pumpkin Msmayy (*Cucurbita pepo* L). The highest number of female flowers was observed in the conditions of using compost which was concluded in an increase in the number and function of the fruit. The results obtained from this experiment express this matter that the diameter of the fruit causes the diameter of squash fruit to be increased in conditions of using three kinds of the studied fertilizers in this experiment, but compost and vermicompost have shown much more effect on the fruit.

Benitez *et al.* (2013) experimented on the bitter gourd (*Momordica charantia* L. cv. Makiling) growing in soil amended with organic fertilizers, namely, Bio-N, commercial compost, and vermicompost, at the rate of 0.075 g/seed, 150 g/plant, and 231 g/plant, respectively. Further, as a positive control, the plants were fertilized with inorganic fertilizer by adding 32.4 g/plant of complete fertilizer (14-14-14) applied basally and 6.52 g per plant of urea side-dressed at flowering based on the recommended application rate of 100 N– 60 P_2O_5 – 60 K_2O kg ha^{-1}, the application of commercial compost resulted in the greatest improvement in both vegetative and reproductive growth as well as in the total herbage and fruit yield of bitter gourd. Plants treated with various organic fertilizers showed enhanced

growth as exhibited by the noticeable increase in vine length, leaf production, and herbage yield over the unfertilized plants. In particular, the total herbage yield was improved by 30%–40% when vermicompost, Bio-N, and commercial compost were applied to the plant. Enhancement of bitter gourd growth brought about by the application of organic amendments can be attributed to their relatively high organic matter content. The vermicompost and the commercial compost used in the study contained about 16x and 13x higher organic matter than the soil, respectively. The presence of a high amount of nutrients in these fertilizer materials as indicated in the results of chemical analysis further accounted for the enhanced growth of bitter gourds. In these studies, the growth-promoting effects of vermicompost have been attributed to the presence of humic substances that can retain moisture and improve soil structure as well as to the diverse microbial population, which plays an important role in increasing soil fertility. The positive response of bitter gourd to the application of organic fertilizers as shown by improved vegetative growth was also reflected in the reproductive and yield parameters measured in these plants.

Anuja and Archana (2011) investigated to find out the effect of soil and foliar application of organic nutrients on flowering and fruit set percentage of bitter gourd (*Momordica charantia*) cv. Long Green. Results of the experiment revealed that the application of FYM @ 25 t ha^{-1} and vermicompost @ 5 t ha^{-1} along with panchagavya 3 percent foliar spray improved the number of female flowers and fruit set percentage of bitter gourd cv. Long Green. The same treatment was found to register the early maturity of fruits.

Azarmi *et al.* (2009) studied an experiment on the effect of sheep-manure vermicompost on quantitative and qualitative properties of cucumber (*Cucumis sativus* L.) grown in the greenhouse. The effect of vermicompost on leaf number and height stem was the same at 30, 60, and 90 days after transplanting. Plants in

plots treated with vermicompost showed an increase in growth parameters like leaf area, chlorophyll content, stem dry weight, and leaf dry weight than with plots receiving inorganic fertilizer only. Leaf number, plant height and chlorophyll content were significantly (P 0.05) affected by vermicompost treatments for both varieties (Sultan F1. and Storm F1 at 30, 60 and 90 days after transplanting. Plots with 20 and 30 t ha^{-1} vermicompost had greater leaf numbers than plot without vermicompost at 30, 60, and 90 days after transplanting for both varieties. Application of vermicompost increased stem heights in response to different rates of vermicompost for both varieties at 30, 60, and 90 days after transplanting. 30 days after transplanting, the highest chlorophyll content was obtained at 20 and 30 t ha^{-1} vermicompost, while at 60 and 90 days after transplanting the maximum chlorophyll content was obtained at 30 t ha^{-1} vermicompost for both varieties. The results showed that the application of vermicompost had a significantly (P 0.05) effect on the leaf area. The plots treated with vermicompost at 30 t ha^{-1} increased leaf area 18% for cv. Sultan F1 and 22% for cv. Storm F1 compared to the control. At 20 and 30 t ha^{-1} of vermicompost, the plants had significantly (P 0.05) greater stem and leaf dry weight than the control. This indicates the positive effects of vermicompost on the growth of cucumber. The results indicated that 20 t ha^{-1} vermicompost was adequate to supply the desired amount of growth-promoting substance for higher growth and yield of cucumber.

Arancon *et al.* (2004) found that the effect of vermicompost on cucumber plant growth could be attributed to the presence of plant growth regulators and humic acid in vermicompost, which is produced by increased activity of microbes such as fungi, bacteria, yeasts, actinomycetes and algae.

Reddy and Rao (2004) was conducted a field experiment with bitter gourd (*M. charantia*) consisting of 4 levels of vermicompost (0, 10, 20 and 30 t/ha) and 3 levels of N (20, 40 and 80 kg/ha). Application of vermicompost and N

significantly increased the vine length, number of branches, number of fruits per vine and fruit yield/ha. Delayed flowering was observed with higher levels of N and Vermicompost. Application of 13.8 t vermicompost and 34.18 kg N (through urea)/ha was found beneficial in improving the yield of bitter gourd.

2.2 Effect of GA_3

Jyoti *et al.* (2016) carried out an experiment to study the influence of different growth regulators on seed yield and seed quality parameters in ridge gourd [*Luffa acutangula* (Roxb) L.]. The results indicated that significantly the highest average fruit weight (32.76 g), matured fruit yield per plant (65.84 g), 100 seed weight (13.41 g), and seed yield per plant (12.79 g) was recorded with the spraying of 500 ppm ethereal, whereas significantly the maximum fruit length (20.89 cm) and fruit diameter (5.15 cm) with 25 ppm GA_3. Significantly the highest seed germination (69.22 %) was recorded with the spraying of 250 ppm ethereal, while application of NAA at 50 ppm recorded significantly the highest vigour index I (2737.85) and vigour index II (5029.33). Spraying of PGR at two to four-leaf stage recorded the higher fruit length (20.19 cm), fruit yield per plant (47.49 g), 100 seed weight (13.18 g) and seed yield per plant (11.98 g) as well as highest germination (60.90%), vigor index I (2460.80) and vigor index II (4377.66). It is concluded that spraying of 500 ppm ethrel at two to four-leaf stage increased the higher fruit length, fruit yield per plant, 100 seed weight and seed yield per plant as well as highest germination, vigor index I and vigor index II.

Sandra et al. (2015) stated that the effect of plant growth regulators on vegetative growth, sex expression, fruit setting, seed yield, and quality was studied for hybrid seed production in the parental lines of bitter gourd (Momordica charantia L.) hybrids, Pusa hybrid 1 and Pusa hybrid 2 in rainy and spring-summer season. Plant growth regulators namely GA_3 @ 50 ppm, NAA @ 200 ppm, maleic hydrazide @ 100 ppm, ethrel @ 50 ppm were sprayed at three-leaves and tendril

initiation stage. The results showed that the application of GA_3 significantly enhanced vine length, number of branches and nodes/vine, fruiting, seed yield and quality in the parental lines in both the seasons. The plants sprayed with growth regulators showed induction of female flowers at lower nodes with 3-5 more pistillate flowers per vine and higher sex ratio as compared to unsprayed control. In manually pollinated flowers, plants sprayed with GA_3 @ 50 ppm had higher fruit and seed set, fruit weight, and hybrid seed yield. All the growth regulators had a positive influence on vegetative, flowering, and fruit traits in both the seasons but the effect of growth regulators were more evident in the rainy than spring and summer season. GA_3 @ 50 ppm, NAA @ 200 ppm, ethrel @ 50 ppm were effective for enhancement in vegetative growth, fruit and seed yield and modification of sex expression but GA_3 @ 50 ppm sprayed twice at three leaves and tendril initiation stage was most effective for hybrid seed production of bitter gourd.

Nagamani *et al.* (2015) studied the effect of plant growth regulators on vegetative growth, sex expression, fruit setting, seed yield and quality for hybrid seed production in the parental lines of bitter gourd (*Momordica charantia* L.) hybrids, Pusa hybrid 1 and Pusa hybrid 2 in rainy and spring-summer season. Plant growth regulators namely GA_3 @ 50 ppm, NAA @ 200 ppm, maleic hydrazide @ 100 ppm, etherel @ 50 ppm were sprayed at three-leaves and tendril initiation stage. The results showed that the application of GA_3 significantly enhanced vine length, the number of branches and nodes/vine, fruiting, seed yield, and quality in the parental lines in both the seasons. The plants sprayed with growth regulators showed induction of female flowers at lower nodes with 3-5 more pistillate flowers per vine and higher sex ratio as compared to unsprayed control. In manually pollinated flowers, plants sprayed with GA_3@ 50 ppm had higher fruit and seed set, fruit weight, and hybrid seed yield. All the growth regulators had a positive influence on vegetative, flowering and fruit traits in both the seasons but

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Geeta et al. (2014) found out the effect of plant growth regulators on leaf biochemical parameters (chlorophyll pigments, sugars, nitrate reductase activity, total phenols) and fruit yield bitter gourd (*Momordica charantia* L.) was studied. The experiment consisted of foliar treatment with three plant growth regulators, GA_3 (20, 40 and 60 ppm), NAA (50 ppm), and CCC (100 and 200 ppm) in two bitter gourd varieties, MHBI-15 and Chaman Plus at 45 days after sowing (DAS). Results revealed a significant difference between treatments on chlorophyll, sugar, total phenol content as also on nitrate reductase activity. Foliar application of CCC (200ppm) recorded the maximum amount of total sugars (18.03% over Control), total phenol content (10.93%) as also nitrate reductase activity (16.12%). Among the treatments, the application of GA_3 (20ppm) recorded maximum chlorophyll content (18.03% over Control). The highest increase in mean fruit yield over Control was recorded with the application of GA_3 (20ppm) (39.88%), followed by CCC (200ppm) (34.15%) in both the cultivars.

Sandra *et al.*, (2015) resulted that NAA @ 200 ppm, GA_3@ 50 ppm, and ethrel @ 50 ppm were very effective for enhancement in vegetative growth, fruit and seed yield, and modification in sex expressions and GA_3 @ 50 ppm was effective in the production of hybrid seed in bitter gourd.

Dalai *et al.*, (2015) reported that GA_3 @ 20 ppm + NAA @ 100 ppm gave highest vine length/plant (cm), no. of leaves/ plant. On the other hand, GA_3 @ 20 ppm + NAA @ 100 ppm gave maximum yield in cucumber.

Mia et al. (2014) found that assessment of growth regulator and NPK fertilization effects are important tools for flower stimulation and yield improvement in cucurbits. This investigation demonstrates the comparative male-female flower induction and fruit yield of small-sized bitter gourd treated with NPK fertilizers and plant growth regulators. Namely, two experiments having three replicates were conducted with NPK fertilization and plant growth regulators- GA_3, NAA and Ethophon application on small-sized bitter gourd-genotype BG5. In experiment 1, different doses of NPK fertilizers comprised 10 treatments and in that of experiment 2, different levels of plant growth regulators indicated 10 treatments. The results indicated that the application of different doses of NPK fertilizer and plant growth regulators significantly (< or = 0.05) influenced the flower initiation and fruit set. The application of N90-P45-K60 fertilizer along with Ethophon spraying resulted in the better yield of small-sized bitter gourd.

Akter and Rahman (2013) experimented to find out the effect of foliar application of IAA And GA on sex expression, yield attributes, and yield of bitter gourd (Momordica Charantia L.). Three concentrations of each of IAA viz. 2.5 (T_1), 5.0 (T_2) and 10 (T_3) ppm and GA_3 *viz.* 2.5 (T4), 5.0 (T_5), and 10 (T_6) ppm were applied as a foliar spray on bitter gourd. Results showed a positive stimulatory effect in the increase of female flowers at T_3 where the male to female sex ratio was the lowest. The number of fruits, fresh weight of fruits, and yield per plant was also found to be the highest at T_3.

Ghani *et al.* (2013) carried out studies to assess the influence of plant growth regulators (PGRs) at different growth stages on sex expression, fruit and seed yield of bitter gourd cv. Faisalabad Long. Three concentrations each of GA_3 (25, 50 & 75 ppm), Ethrel (400, 500 & 600 ppm), and NAA (50, 100 & 150 ppm) were applied at three different stages namely S_1 (2-leaf stage), S_2 (2-leaf and flower initiation stage) and S_3 (2-leaf, flower and fruit initiation stage). Application of GA_3 @ 25 ppm significantly reduced the number of days to first flower (40 days)

and first harvest (54 days) at S_3. Similarly male to female flower ratio was lowest (11.83) in plants sprayed with GA_3 @ 75 ppm at S1 while the fruit set percentage was highest (90%) with the similar application at S_2; however, both fruit length and fruit diameter were highest with similar dose in plants sprayed at S_2. The number of fruits and seed yield $vine^{-1}$ was significantly higher among all the PGRs (GA_3, ethrel and NAA) when plants were sprayed with NAA @ 100 ppm at S_2 and S_1, respectively. Overall results revealed that the application of NAA proved to be better for different yield and yield-related traits in bitter gourd.

Biradar et al. (2012) reported that the bitter gourd is an important vegetable crop since its fruits are brought to use either as a vegetable or medicinal purposes. A compound known as charantin, present in the bitter gourd is used in the treatment of diabetes in reducing blood sugar levels. In the present day due to the increase in the number of diabetic patients, there is more demand to meet the requirement. The available literature on cucurbits said that, growth regulators had a significant effect on the conversion of sex ratio of flowers, which helps in enhancing the yields of the crop. Keeping this as an objective a study on the Effect of plant growth regulators on yield, biochemical and physiological characters of bitter gourd (*Momordica charantia* L.) was conducted. Foliar application of the plant growth regulators such as Gibberellic acid (GA_3) at 20, 40, and 60ppm, naphthalene acetic acid (NAA) at 50ppm and cystocele (CCC) at 100 and 200 ppm, was done at 45 days after sowing. Application of plant growth regulators significantly increased the biochemical and physiological characters in bitter gourds such as chlorophyll content (Chl a, Chl b and total chlorophyll), nitrate ReductaseActivity (NRA), sugar content (reducing, non-reducing and total sugars), and total phenol content. Among the different treatments, GA_3 @ 20 ppm was most effective in increasing shoot length, leaf area, fruit yield, and yield components such as No. of female flowers, no of fruits per plant as compared to control.

Hidayatullah *et al.*, (2012) revealed that GA_3 @ 30 ppm increased in the production of pistillate flowers, maximum no. of fruits, and fruit weight as compared to control in bottle gourd.

Shahzad (2012) mentioned, the improvement in the growth of plants is important in present-day life, where food and its quality often fall short. With the steady population growth, it is certainly important to ensure plants are used for food and otherwise are grown in optimum conditions and have a high yield. This book covers a study conducted to evaluate the growth response of the bitter gourd plant *Momordica charantia* to growth regulator treatments of the hormone Gibberellic acid to determine the optimum concentration required for enhanced growth. Gibberellin increases both cell elongation and cell division, as evidenced by increases in cell length and cell number in response to applications of GA. This book should help the botanists and agriculturists around the world to observe the best growth in plants and serve as an example for future publications that also focus on plant growth regulators.

According to, Ashrafuzzaman et al. (2010), an experiment was conducted to investigate the effect of GABA (GA_3 1% & SBA Brassicasteroids as STC 0.3%) application on growth, yield, and yield contributing traits of bitter gourd. GABA was applied at 0.5, 1.0, 1.5 and mg L^{-1} as a foliar spray at 30 days after sowing, while control plants received no GABA. The experiment was laid out in a randomized complete block design (RCBD) with four replications. The result showed that GABA had a positive regulatory effect on morphological growth, yield, and yield-related traits of the bitter gourd; nonetheless, GABA application at 1.5 mg L^{-1} was found the most effective in improving the length and diameter of the main vine, individual branch length, number of branches, total branch length, number of nodes per plant, vine diameter, days to the first male and female flowering, numbers of male and female flower, number of fruit, the weight of individual fruit, length and diameter of fruit, percentage of fruit set and number of

seeds per fruit. Hence GABA application at mg L^{-1} as foliar spray could be the suitable concentration for enhancing growth and yield of bitter gourd.

Hossain et al. (2006) reported that, the flowering and fruiting of two varieties of bitter gourd (Tia and Biruttam) as affected by six levels of GA_3 concentrations *viz*. 0, 25, 40, 55, 70 and 85 ppm was studied during the period from February to May 2005. Application of GA_3 at the pre-flowering stage in bitter gourd plant significantly influenced flowering behavior and fruiting characteristics. It was observed that individual fruit weight was the maximum by application of GA_3 at 40 ppm but at higher concentration (>40 ppm) fruit yield declined. The results showed that variety Tia produced a higher yield (1.454 kg/plant) than the variety Biruttam (1.367 kg/plant). The effect of different levels of GA_3 concentrations was statistically different from each other.

David *et al*. (2005) found that plants treated with GA_3 showed significantly greater plant height, number of branches/plant, number of fruit/plant and yield than untreated controls. GA_3 treatment at the seedling stage offered valuable scope for obtaining higher commercial tomato yields.

Wang (2001) conducted an experiment on the effect of CPPU (forchlorfenuron) application on growth and endogenous phytohormone contents of *M. charantia* cv. Kaihua Changbai was determined. Application of CPPU to the ovary at anthesis within the concentration of 10-50 mg/litre accelerated fruit growth by increasing the length, diameter, and fresh weight of fruits, while 100 mg/litre inhibited fruit growth. HPLC analysis showed that the endogenous ZT (zeatin) content of fruit was lowered and the endogenous ABA (abscisic acid) content was improved by CPPU treatments at the concentration of 20 and 100 mg/litre, and that the endogenous contents of IAA and GA_3 (gibberellic acid) were significantly improved by application of CPPU at 20 mg/liters, reaching a peak value 6 days after anthesis.

Gedam *et al.* (1998) conducted an experiment in 1992 where bitter gourd plants were sprayed 40, 55, 70, 80 and 100 days after sowing with 15, 25, and 35 ppm GA_3, 50, 100, and 150 ppm NAA, 50, 100 and 150 ppm Ethephon, 100, 200, 200 and 300 ppm Maleic Hydrazide, 2, 4 and 6 ppm boron and with water (control). GA_3 at 35 ppm produced the earliest female flower and NAA at 50 ppm produced the earliest male flower. Fruit maturity was the earliest in plants treated with 50 ppm NAA or 4 ppm boron. Fruit and seed yields were also the highest in these treatments.

Tomar and Ramgiry (1997) conducted an experiment and found that plants treated with GA_3 showed significantly greater plant height, number of branches/plant, number of fruit/plant, and yield than untreated controls. GA_3 treatment at the seedling stage offered valuable scope for obtaining higher commercial tomato yields.

Islam (1995) conducted a trial with different concentrations of GA_3 like 0, 10, 25, 50 and100 ppm. He stated that the application of GA_3 was effective in improving the yield and yield components of the bitter gourd when applied at a low concentration of 10 ppm. The inhibitory effect of GA_3 applied at the rate of 100 ppm was observed on the production of fruits with a lesser number of filled seeds, dry matter of seeds, weight of 100 seeds, seed yield and percent seed vigor index. Irrespective of concentration, the application of GA_3 reduced the total number of staminate flowers. The ratio between the staminate and pistillate flowers as well as fruit setting was low. The number, length, diameter, and weight of fruits were not influenced by the GA_3 application.

From the above review of literature, it can be concluded that vermicompost has a promising effect on bitter gourd production. GA_3 possesses a significant effect on the growth and development of bitter gourd. Cultivation of vegetables on pond

water surface under floating agriculture is also a promising practice for increasing the area and production of vegetables.

CHAPTER III

MATERIALS AND METHODS

The experiment was undertaken to study the response of vermicompost and gibberellin on bitter gourd production in the water surface of a fish pond. This chapter deals with the materials and methods that were used in conducting the study. It consists of a short description of the location of the experimental plot, characteristics of soil, climate, the material used, treatments, layout, and design of experiment, land preparation, seed sowing, transplanting of seedling and intercultural operations, harvesting, and collection of data. These are described below:

3.1 Experimental site

This experiment was carried out on a fish pond near the Horticulture farm at the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh during the period from March to June 2019. The location of the experimental site was 23°74′N latitude and 90°35′E longitude at an altitude of 8.6 meters above the sea level (Anon., 2004), which have been shown in Appendix I.

3.2 Climatic conditions

The experimental site is situated in the subtropical monsoon climatic zone. Generally, this zone is characterized by heavy rainfall during the months from April to November in Kharif season. The overall weather condition at the experimental site during the cropping season March to June 2019 has been presented in Appendix II including minimum and maximum temperature, rainfall, relative humidity and sunshine hours, etc.

3.3 Characteristics of pond water

Physical and chemical analysis of pond water where the present study was conducted was done in the Laboratory of Fisheries Biology and Genetics, Sher-e-Bangla Agricultural University, Dhaka-1207. The characteristics of pond water have been presented in Appendix III.

3.4 Planting materials

Seeds of high yielding corolla- (Rani pukur) were purchased from Krishibid Nursery, Sher-e-Bangla Nagar, Dhaka, and used for the present study.

3.5 Treatments of the experiment

The experiment consisted of two factors:

Factor A: Vermicompost

1. V_0 = 90% coco peat + 10% broken bricks (Control)
2. V_1 = 30% vermicompost +60% coco peat/pot + 10% broken bricks
3. V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

Factor B: Gibberellic acid

1. G_0 = 0 ppm GA_3 (Control)
2. G_1 = 40 ppm GA_3

3.6 Design and layout of the experiment

The experiment was laid out in a Completely Randomized Design (CRD) with three replications. The 18 plants were planted in the 18 plastic pots. One plant was

transplanted per plastic pot. The plastic pot size was 21 cm in height with a depth of 17 cm. The layout of the experiment is presented in Appendix IV.

3.7 Sowing of seeds and transplanting of seedling

Seeds were sown in polybags having compost mixed soil on 2nd March 2019 for germination and seedling raising. Two seeds were sown in each polybag. The polybags were kept in a shady place. They were watered regularly during the seedling-raising period. When the seedlings (15 days old) attained 4 leaves and hard enough, one seedling was removed keeping another healthy and vigorous seedling in each polybag. One seedling was transplanted in each pot on 16 March 2019.

3.8 Raft preparation

The raft was prepared by cork sheet and bamboo slits strongly tied with rope. The raft was 3 ft in length and 2 ft in breadth. The prepared raft was shown in Appendix XI.

3.9 Pot preparation

Before transplanting of seedling, the pots were prepared with coco peat, broken bricks, and vermicompost according to the treatment assigned. Pots were made completely stubbles and weed-free.

3.10 Manure and fertilizer application

No chemical fertilizer was used. The only vermicompost was used according to the treatments in each pot.

3.11 Application of growth regulator

The selected growth regulator (GA_3) was applied at three times, first at 20 days after transplanting (DAT), second after 35 DAT and third at 50 DAT with the help of hand sprayer.

3.12 Intercultural operations

Intercultural operations were done whenever needed for better growth and development. Intercultural operations followed in the experiment were irrigation, weeding, staking, and top dressing, etc.

3.12.1 Stalking

Stalking was given to each plant by bamboo sticks for support when the plants were well established.

3.12.2 Weeding

Weeding was done whenever it was necessary, mostly in the vegetative stage for better growth and development.

3.12.3 Vine management

Stormy weather may cause the tendering vine of the plants fell down from the supports (Trellis). For proper growth and development of the plants, the vines were managed upward with the help of iron rope by hand. Sample vine management was showed in Appendix XII.

3.12.4 Pest control

Severe insect attack was not found during cropping duration and also there was no incidence of disease. So, no insecticide and fungicide was applied to the crop during the experimental period.

3.13 Harvesting

Total of 6 times harvesting was done started from 10 April, 2019. Harvesting was done at 5 days interval from every plant of every pot for collecting data.

3.14 Data collection

Experimental data were recorded from 25 days after transplanting (DAT) and continued until the last harvest. The following data were recorded during the experimental period.

3.14.1 Growth parameters

1. Vine length (cm)
2. Number of leaves plant^{-1}
3. Number of branches plant^{-1}
4. Leaf area

3.14.2 Yield contributing parameters

1. Days to 1st flowering
2. Number of male flowers
3. Number of female flowers
4. Percent (%) fruit set
5. Fruit length (cm)
6. Fruit diameter (cm)

3.14.3 Yield parameters

1. Number of fruits pot^{-1}
2. Single fruit weight (g)
3. Fruit weight pot^{-1} (g)
4. Fruit yield (t ha^{-1})

3.15 Procedure of Recording Data

3.15.1 Vine length

The Vine length was measured from the sample plants in centimeter from the ground level to the tip of the highest leaf and the means value was calculated. To observe the growth rate plant height was recorded at 25, 40, and 60 days after planting.

3.15.2 Number of leaves plant^{-1}

The number of leaves plant^{-1} was measured from the sample plants and total leaves were counted from each plant of each pot considering each replication and mean value was calculated. The number of leaves plant^{-1} was recorded at 25, 40, and 60 DAT.

3. 15.3 Number of branches plant^{-1}

The total number of branches plant^{-1} was counted from each pot at 25, 40, and 60 DAT.

3.15.4 Leaf area (cm^2)

Leaf area was measured by leaf area meter and was expressed in cm^2 from each plant of each pot. It was measured at 50 DAT.

3.15.5 Days to first flowering (days)

The number of days from transplanting to the time required to the first flower was recorded for every plant of each pot and the average was calculated.

3.15.6 Number of male and female flowers

The total number of male and female flowers was counted from each plant of each pot. It was done at ten days interval after first flowering to ensure all flowers to be counted.

3.15.7 Percent fruit set (%)

To obtain percent fruit set, the total number of flowers and fruits per plant was counted and percent fruit set was measured using the following formula-

$$\text{Percent fruit set (\%)} = \frac{\text{Total number of fruits}}{\text{Total number of flowers}} \times 100$$

3.15.8 Length and diameter of fruit

The length of 10 randomly selected fruits per pot was measured after each harvest and then the average was taken. A total of 6 times measurement was taken during

the total experiment period. The diameter of the same 10 randomly selected fruits as harvested was measured and the average was calculated in cm.

3. 15.9 Number of fruits per plant

The number of fruits in every plant of each pot of bitter gourd was counted at every harvest and thus the total number of fruits per plant was recorded and the average number of fruits was recorded.

3. 15.10 Weight of single fruit (g)

After each harvest, the weight of randomly selected 10 fruits per pot was recorded and then the average weight per fruit was calculated.

3.15.11 Fruit weight plant^{-1}

To estimate weight plant^{-1}, all fruits weight from the plant of each pot was recorded from six harvest and total weight were recorded. Thus the yield per plot was measured.

3.15.12 Fruit yield

To estimate yield, all the fruits of each plant of each pot was considered. Thus the average yield per plot was measured. The yield per hectare was calculated considering the area covered by each pot.

3.16 Statistical Analysis

The recorded data on different parameters were statistically analyzed using MSTAT software to find out the significance of variation resulting from the experimental treatments. The mean for the treatments was calculated and analysis of variance for each of the characters was performed by F (variance ratio) test. The

differences between the treatment means were evaluated by the LSD test at 5% probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to determine the response of vermicompost and gibberellin of bitter gourd on pond water. This chapter comprises the arrangement and discussion of the results obtained due to the application of three different vermicompost and two different GA_3 applications on bitter gourd. The analyses of variance (ANOVA) of the data on different components are given in Appendix V to X. The results have been presented, discussed, and possible interpretations have been given under the following headings:

4.1 Growth parameters

4.1.1 Vine length (cm)

Effect of vermicompost

In terms of vine length at different growth stages in relation to different vermicompost doses, results were varied significantly under the trial (Fig. 1 and Appendix V). Results revealed that the highest vine length (43.05, 93.10 and 128.30 cm at 25, 40 and 60 DAT, respectively) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) followed by V_1 (30% vermicompost + 60% coco peat/pot + 10% broken bricks). The lowest vine length (29.98, 74.11, and 100.70 cm at 25, 40, and 60 DAT, respectively) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). Under the present study, control treatment also showed comparatively better results, might be due to the presence of nutrients in pond water which was uptake by the root system of bitter gourd. The results indicated gradually increased vine length was achieved with increased levels of vermicompost and the tallest plant was produced at different growth stages by the maximum application of vermicompost than that of control with ensuring better growth and development.

A similar result was also observed by Azarmi *et al.* (2009) and Nagar *et al.* (2017) which supported the present study.

Effect of GA_3

Remarkable variation was observed on vine length at different growth stages influenced by GA_3 applications (Fig. 2 and Appendix V). Results showed that the highest vine length (40.13, 90.50, and 124.25 cm at 25, 40, and 60 DAT, respectively) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest vine length (33.38, 81.05, and 110.43 cm at 25, 40 and 60 DAT, respectively) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that the tallest plant at different growth stages was produced by the application of GA_3 compared to control. Almost same result was also observed by David *et al.* (2005) and Sandra *et al.* (2015) and they found that plants treated with GA_3 showed significantly greater plant height than untreated controls.

Interaction effect of vermicompost and GA_3

There was a significant variation was found on vine length at different growth stages influenced by the interaction of vermicompost and GA_3 (Table 1 and Appendix V). It was observed that the highest vine length (46.50, 98.18, and 136.60 cm at 25, 40, and 60 DAT, respectively) was found from the treatment combination of V_2G_1 which was significantly different from all other treatment combinations. The lowest vine length (28.65, 69.02, and 94.67 cm at 25, 40, and 60 DAT, respectively) was obtained from the treatment combination of V_0G_0 which was also significantly different from all other treatment combinations. The results indicated that the combination of vermicompost and GA_3 ensures the optimum condition for the growth and development of bitter gourd and the ultimate result is the longest plant at different growth stages.

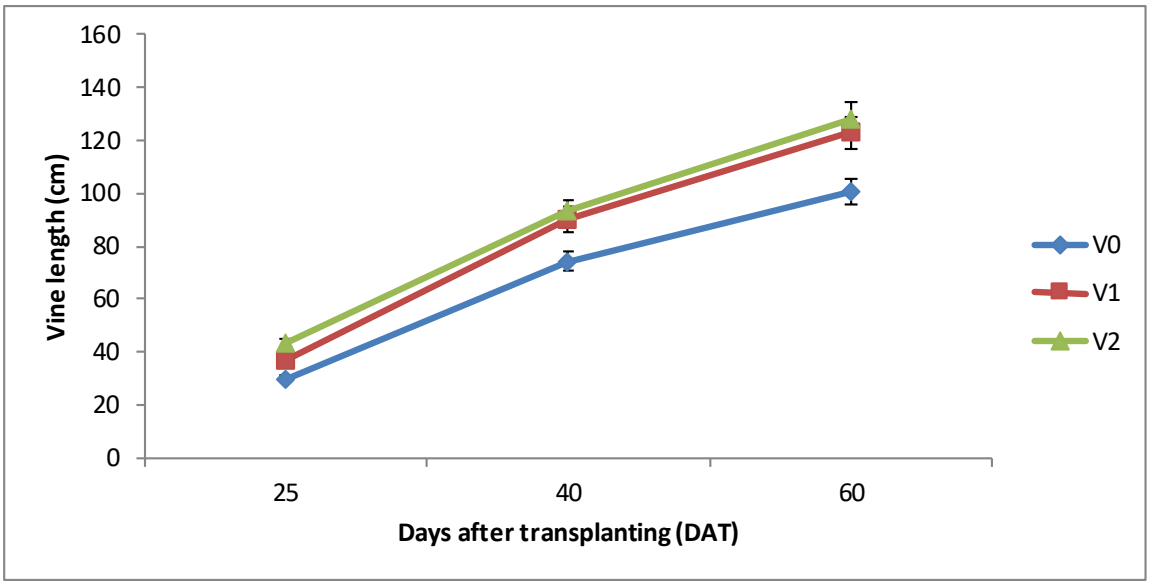

Figure 1. Vine length of bitter gourd as influenced by vermicompost on water surface of fish pond ($LSD_{0.05}$ = 2.398, 2.005 and 2.332 at 25, 40 and 60 DAT, respectively)

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

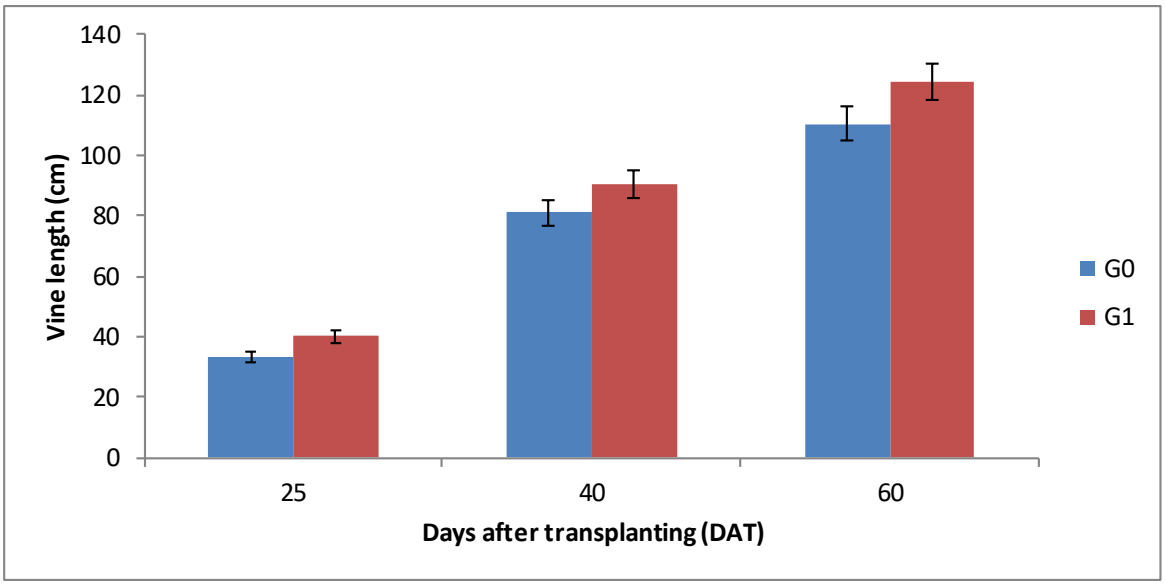

Figure 2. Vine length of bitter gourd as influenced by gibberellins on water surface of fish pond ($LSD_{0.05}$ = 2.815, 2.309 and 2.516 at 25, 40 and 60 DAT, respectively)

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

Table 1. Vine length of bitter gourd as influenced by vermicompost and gibberellins on water surface of fish pond

Treatments	Vine length (cm)		
	25 DAT	40 DAT	60 DAT
V_0G_0	28.65 c	69.02 e	94.67 f
V_0G_1	31.30 c	79.20 d	106.80 e
V_1G_0	31.90 c	86.10 c	116.60 d
V_1G_1	42.60 b	94.12 b	129.30 b
V_2G_0	39.60 b	88.01 c	120.00 c
V_2G_1	46.50 a	98.18 a	136.60 a
$LSD_{0.05}$	3.391	2.836	3.298
CV(%)	8.59	6.29	9.09

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

4.1.2 Number of leaves plant^{-1}

Effect of vermicompost

In terms of number of leaves plant^{-1} at different growth stages in relation with different vermicompost doses, results were varied significantly under the present study (Fig. 3 and Appendix VI). Results revealed that the highest number of leaves plant^{-1} (79.50117.30 and 129.30 at 25, 40 and 60 DAT, respectively) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) followed by V_1 (30% vermicompost + 60% coco peat/pot + 10% broken bricks). The lowest number of leaves plant^{-1} (38.73, 73.33 and 86.67 at 25, 40 and 60 DAT, respectively) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). Control treatment also showed better result on number of leaves plant^{-1} which might be due to presence of nutrients in pond water which was uptake by root system of bitter gourd. The results indicated gradually increased number of leaves plant^{-1} was obtained along with the increased levels of vermicompost. In addition, The highest number of leaves plant^{-1} was produced at different

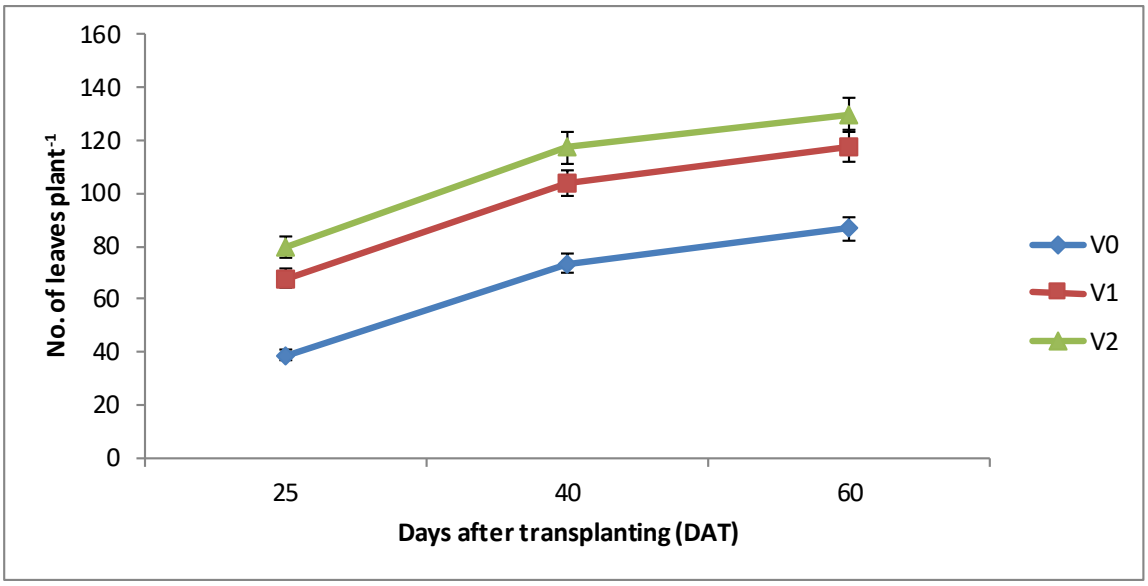

Figure 3. Number of leaves plant^{-1}of bitter gourd as influenced by vermicompost on water surface of fish pond ($LSD_{0.05}$ = 2.605, 3.445 and 4.055 at 25, 40 and 60 DAT, respectively)

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

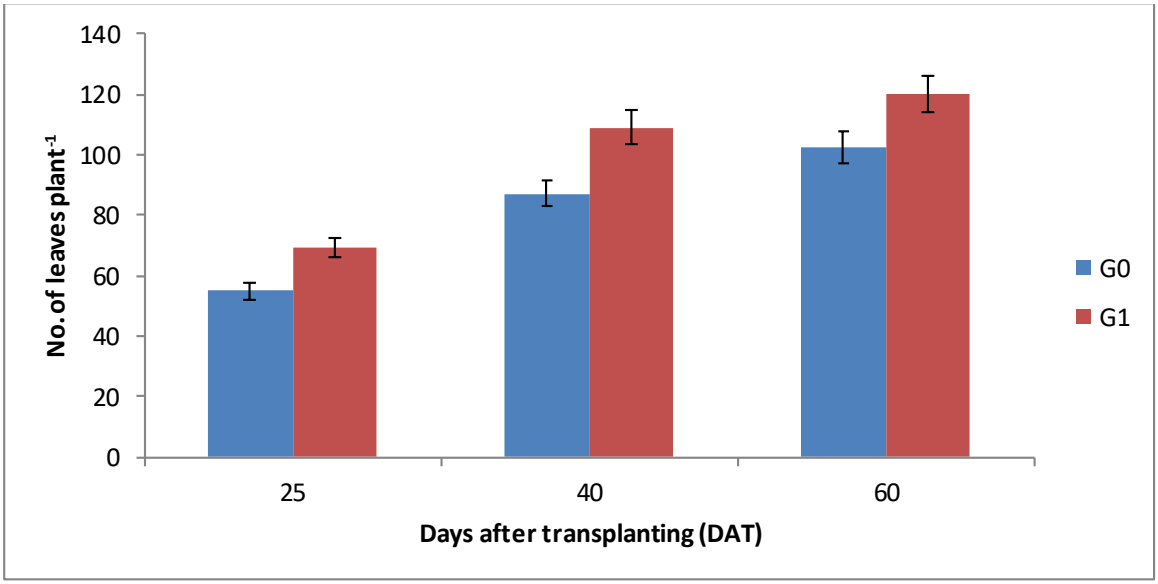

Figure 4. Number of leaves plant^{-1} of bitter gourd as influenced by gibberellins water surface of fish pond ($LSD_{0.05}$ = 1.362, 3.417 and 3.614 at 25, 40 and 60 DAT, respectively)

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

growth stages by the maximum application of vermicompost than that of control treatment which ensure the better growth and development. The research of Nagar *et al.* (2017) positively support the present study.

Effect of GA_3

Remarkable variation was observed on the number of leaves plant^{-1} at different growth stages influenced by GA_3 applications (Fig. 4 and Appendix VI). Results showed that the highest number of leaves plant^{-1} (69.22, 109.11, and 120.22 at 25, 40, and 60 DAT, respectively) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest number of leaves plant^{-1} (54.89, 87.22 and 102.33 at 25, 40 and 60 DAT, respectively) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that the highest number of leaves plant^{-1} at different growth stages was produced by the application of GA_3 compared to control. A similar result was also observed by Sandra *et al.* (2015).

Interaction effect of vermicompost and GA_3

There was a significant variation was found on the number of leaves plant^{-1} at different growth stages influenced by the interaction of vermicompost and GA_3 (Table 2 and Appendix VI). It was observed that the highest number of leaves plant^{-1} (84.67, 130.70, and 139.00 at 25, 40, and 60 DAT, respectively) was found from the treatment combination of V_2G_1 which was significantly different from all other treatment combinations. The lowest number of leaves plant^{-1} (33.67, 65.00, and 80.00 at 25, 40, and 60 DAT, respectively) was obtained from the treatment combination of V_0G_0 which was also significantly different from all other treatment combinations. The results indicated that a combination of vermicompost and GA_3 ensures the optimum condition for the growth and development of bitter

gourd and the ultimate result is the highest number of leaves plant^{-1} at different growth stages.

Table 2. Number of leaves plant^{-1} of bitter gourd as influenced by vermicompost and gibberellins on water surface of fish pond

Treatments	Number of leaves plant^{-1}		
	25 DAT	40 DAT	60 DAT
V_0G_0	33.67 f	65.00 f	80.00 f
V_0G_1	44.00 e	81.67 e	93.33 e
V_1G_0	56.67 d	92.67 d	107.3 d
V_1G_1	79.00 b	115.0 b	128.3 b
V_2G_0	74.33 c	104.0 c	119.7 c
V_2G_1	84.67 a	130.7 a	139.0 a
$LSD_{0.05}$	4.536	4.536	5.153
CV(%)	5.74	6.14	6.29

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

4.1.3 Number of branches plant^{-1}

Effect of vermicompost

Statistically, significant variation was found for the number of branches plant^{-1} at different growth stages for different vermicompost management (Fig. 5 and Appendix VII). The highest number of branches plant^{-1} (3.81, 9.25 and 13.17 at 25, 40 and 60 DAT, respectively) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) followed by V_1 (30% vermicompost + 60% coco peat/pot + 10% broken bricks) whereas the lowest number of branches plant^{-1} (2.43, 5.52 and 10.11 at 25, 40 and 60 DAT, respectively) was obtained from the control treatment V_0 (90% coco peat + 10%

broken bricks). From Appendix IV, it was found that pond water also contained some plant nutrients which was uptake by the root system of bitter gourd and that is why control treatment also showed comparatively better result on number of branches plant^{-1}. These results indicated that maximum number of branches plant^{-1}

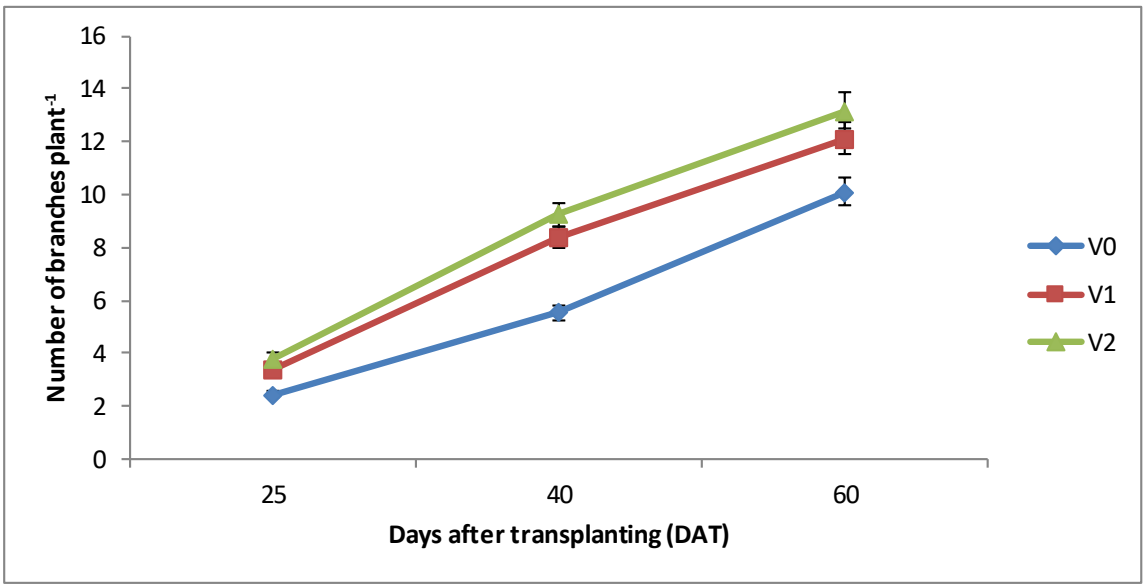

Figure 5. Number of branches plant^{-1} of bitter gourd as influenced by vermicompost on water surface of fish pond ($LSD_{0.05}$ = 0.141, 0.276 and 0.287 at 25, 40 and 60 DAT, respectively)

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

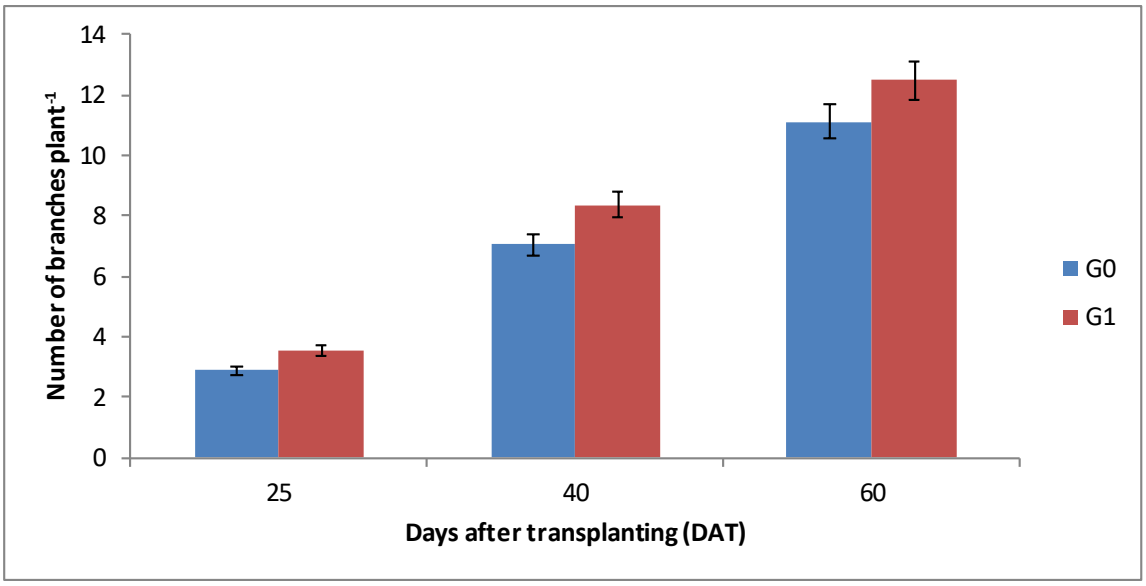

Figure 6. Number of branches plant^{-1} of bitter gourd as influenced by gibberellins on water surface of fish pond ($LSD_{0.05}$ = 0.133, 0.214 and 0.236 at 25, 40 and 60 DAT, respectively)

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

were produced by the higher rate of vermicompost than the control, which ensure the maximum number of fruit per hactre and yield of bitter gourd. The result obtained from the present study was almost identical with the findings of Sureshkumar *et al.* (2019), Nagar *et al.* (2017) and Thriveni *et al.* (2015).

Effect of GA_3

Number of branches plant^{-1} at different growth stages for plant growth regulators showed statistically significant variation (Fig. 6 and Appendix VII). The highest number of branches plant^{-1} (3.52, 8.38 and 12.49 at 25, 40 and 60 DAT, respectively) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest number of branches plant^{-1} (2.90, 7.05 and 11.11 at 25, 40 and 60 DAT, respectively) was obtained from the control treatment G_0 (0 ppm GA_3). This results indicated that maximum branches per plant were produced by the

application of GA_3 comparing with control. These results goes with the studies of Sandra *et al.* (2015) and Nagamani *et al.* (2015).

Table 3. Number of branches plant^{-1} of bitter gourd as influenced by vermicompost and gibberellins on water surface of fish pond

Treatments	Number of branches plant^{-1}		
	25 DAT	40 DAT	60 DAT
V_0G_0	2.100 f	4.940 f	9.500 f
V_0G_1	2.750 e	6.100 e	10.73 e
V_1G_0	3.050 d	7.850 d	11.63 d
V_1G_1	3.750 b	8.880 b	12.61 b
V_2G_0	3.550 c	8.350 c	12.20 c
V_2G_1	4.060 a	10.15 a	14.14 a
$LSD_{0.05}$	0.1991	0.3898	0.4064
CV(%)	5.33	6.97	6.34

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

Interaction effect of vermicompost and GA_3

The interaction effect of vermicompost and GA_3 showed statistically significant variation in consideration of the number of branches plant^{-1} at different growth stages (Table 3 and Appendix VII). The highest number of branches plant^{-1} (4.06, 10.15, and 14.14 at 25, 40, and 60 DAT, respectively) was found from the treatment combination of V_2G_1 which was significantly different from all other treatment combinations at all growth stages. The lowest number of branches plant^{-1} (2.10, 4.94, and 9.50 at 25, 40 and 60 DAT, respectively) was obtained from the treatment combination of V_0G_0. This result indicated that the combination of vermicompost and GA_3 ensures the optimum condition for the branches' growth and development of bitter gourd and resulted maximum number of branches plant^{-1} from V_2G_1 and as a result number of fruit also increases.

4.1.4 Leaf area (cm^2) at 50 DAT

Effect of vermicompost

The considerable influence was observed on leaf area at 50 DAT persuaded by vermicompost at different rates (Fig. 7 and Appendix VIII). Results revealed that the highest leaf area at 50 DAT (69.37 cm^2) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) whereas the lowest leaf area at 50 DAT (48.38 cm^2) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). Here, it was also observed that pond water also served as a source of plant nutrients and that is why plants under control treatment also performed better leaf areas. This result indicated that the maximum leaf area was produced by the higher rate of vermicompost than the control, which ensures the optimum growth and development of bitter gourd. Azarmi *et al.* (2009) and Nagar *et al.* (2017) also found a similar result which supported the present study.

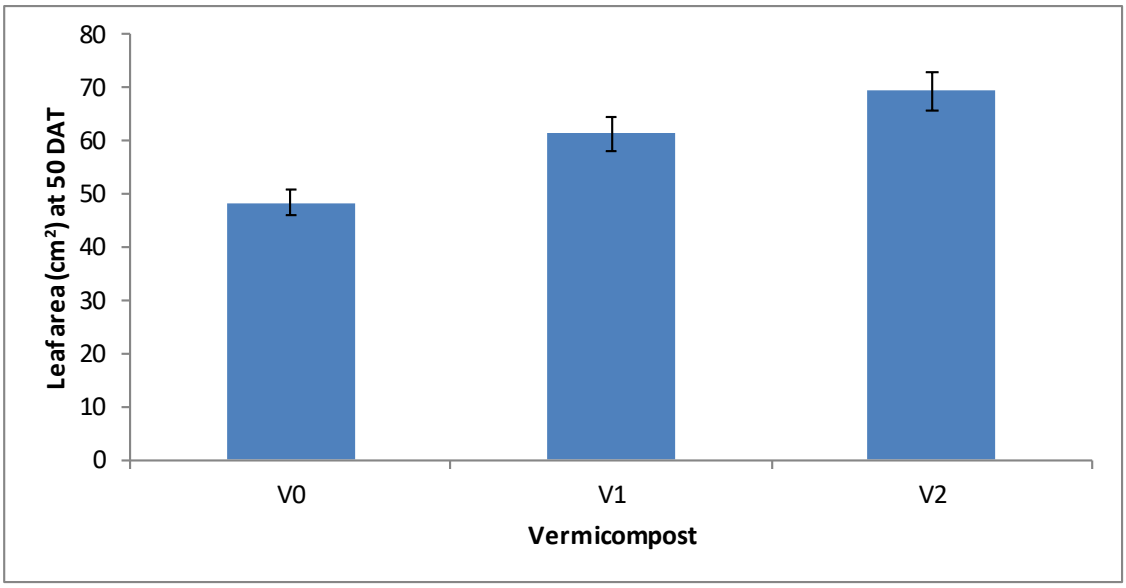

Figure 7. Leaf area of bitter gourd as influenced by vermicompost on water surface of fish pond ($LSD_{0.05}$ = 2.723)

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

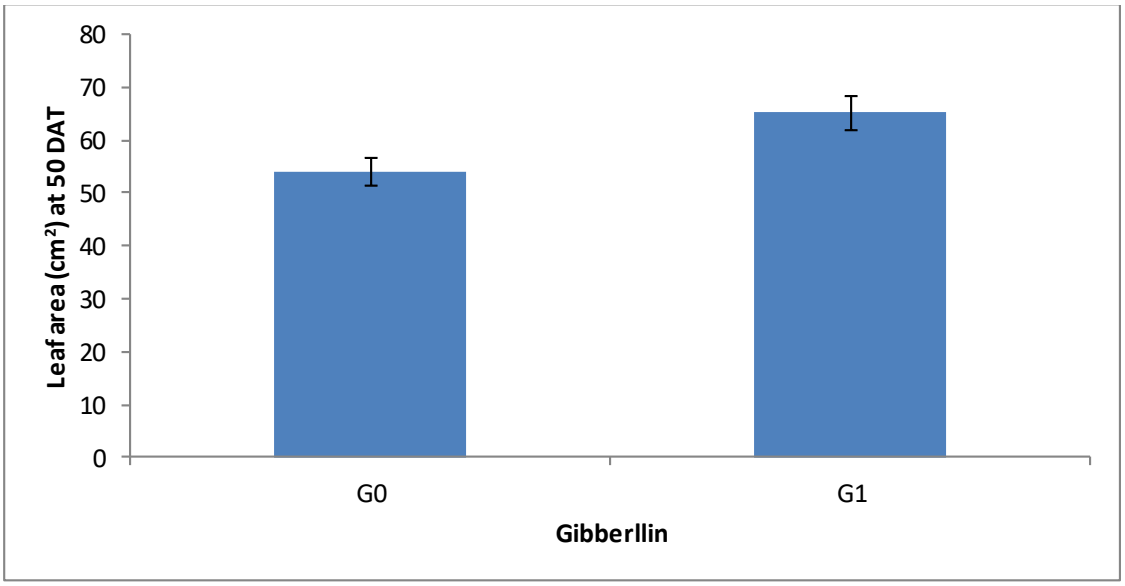

Figure 8. Leaf area of bitter gourd as influenced by gibberellins on water surface of fish pond ($LSD_{0.05}$ = 3.077)

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

Effect of GA_3

The recorded data on leaf area at 50 DAT was significantly influence by GA_3 application (Fig. 8 and Appendix VIII). The highest leaf area (65.28 cm^2) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest leaf area (54.09 cm^2) was obtained from the control treatment G_0 (0 ppm GA_3). This result indicated that maximum leaf area was produced by the application of GA_3 compared to control. Biradar *et al.* (2012) also found similar results and found that leaf area increased with GA_3 application compared to control.

Interaction effect of vermicompost and GA_3

Remarkable variation was identified on leaf area at 50 DAT due to the effect of GA_3 application (Table 4 and Appendix VIII). The highest leaf area (77.45 cm^2) was found from the treatment combination of V_2G_1 whereas the lowest leaf area (45.50 cm^2) was obtained from the treatment combination of V_0G_0. This result indicated that combination of vermicompost and GA_3 ensure the optimum growth and development of bitter gourd and resulted leaf area from the treatment combination of V_2G_1 compared to all other treatment combinations.

Table 4. Leaf area of bitter gourd as influenced by vermicompost and gibberellins on water surface of fish pond

Treatments	Leaf area (cm^2) at 50 DAT
V_0G_0	45.50 f
V_0G_1	51.26 e
V_1G_0	55.47 d
V_1G_1	67.13 b
V_2G_0	61.29 c
V_2G_1	77.45 a
$LSD_{0.05}$	3.851
CV(%)	7.51

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

4.2 Yield contributing parameters

4.2.1 Days to 1st flowering

Effect of vermicompost

Different levels of vermicompost showed a statistically significant variation on days to 1st flowering (Table 5 and Appendix IX). The minimum days to 1st flowering (25.00) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) whereas the maximum days to 1st flowering (27.25) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). The treatment V_1 (30% vermicompost + 60% coco peat/pot + 10% broken bricks) showed intermediate result. The results indicated that the minimum time of the first flower was recorded by the application of vermicompost than the control with ensuring the better growth and development of bitter gourd. The result obtained from the present study was conformity with the findings of Thriveni *et al.* (2015).

Effect of GA_3

Different GA_3 levels showed a statistically significant variation on days to 1st flowering (Table 6 and Appendix IX). Results revealed that the minimum days to 1st flowering (25.50) was found from the treatment G_1 (40 ppm GA_3) where the maximum days to 1st flowering (26.50) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that GA_3 promoted early flowering and the minimum time of the first flower was produced by the application of GA_3 comparing with the control. A similar result was also observed by Ghani *et al.* (2013) and Ashrafuzzaman *et al.* (2010) which supported the present finding of the study.

Interaction effect of vermicompost and GA_3

Interaction effect between vermicompost and GA_3 showed a statistically significant variation in consideration days to 1st flowering (Table 7 and Appendix IX). Results indicated that the maximum days to 1st flowering (24.00) was found from the treatment combination of V_2G_1. The maximum days to 1st flowering (27.50) was obtained from the treatment combination of V_0G_0 which was statistically identical with V_0G_1. The results indicated that vermicompost and GA_3 ensure the optimum condition for the growth and development of bitter gourd and the ultimate result is the minimum time to first flower.

Table 5. Yield contributing parameters of bitter gourd as influenced by vermicompost on water surface of fish pond

Treatments	Yield contributing parameters					
	Days to 1st flowering	Number of male flowers	Number of female flowers	% fruit set	Fruit length (cm)	Fruit diameter (cm)
V_0	27.25 a	26.30 c	21.35 c	31.51 b	10.06 c	5.80 c
V_1	25.75 b	29.20 b	24.52 b	34.80 a	12.80 b	7.28 b
V_2	25.00 c	30.67 a	26.34 a	36.23 a	13.61 a	7.81 a
$LSD_{0.05}$	0.6629	1.151	1.421	2.113	0.5862	0.152
CV(%)	8.39	7.16	10.42	4.91	8.39	7.16

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

4.2.2 Number of male flowers

Effect of vermicompost

In terms of male flower in number for different vermicompost doses, a statistically significant variation was recorded under the trial (Table 5 and Appendix IX). It was observed that the highest number of male flowers (30.67) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) whereas the lowest number of male flowers (26.30) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). The results indicated that the minimum male flower in number was produced in the control condition. Sundararasu (2017) also found similar results on the number of male flowers that supported the present findings of the study.

Effect of GA_3

Different levels of GA_3 showed a statistically significant variation in the number of male flowers (Table 6 and Appendix IX). Results revealed that the highest number of male flowers (30.17) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest number of male flowers (27.28) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that a minimum male flower was produced in control comparing with the application of GA_3. The supported result was also observed by Ghani *et al.* (2013) and Ashrafuzzaman *et al.* (2010).

Interaction effect of vermicompost and GA_3

The interaction effect of vermicompost and GA_3 application showed a statistically significant variation in consideration of male flower in number (Table 7 and Appendix IX). Results showed that the highest number of male flowers (32.50) was found from the treatment combination of V_2G_1 which was significantly different from all other treatment combinations. The lowest number of male flowers (25.20) was obtained from the treatment combination of V_0G_0. The results on the number of male flowers obtained from the present study indicated that higher doses of vermicompost combination with GA_3 ensure the higher flowering of bitter gourd.

4.2.3 Number of female flowers

Effect of vermicompost

A statistically significant variation was recorded in the number of female flowers for different fertilizer vermicompost levels (Table 5 and Appendix IX). It was observed that the highest number of female flowers (26.34) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) which was significantly different from other treatments whereas the lowest number of female flowers (21.35) was obtained from the control treatment V_0

(90% coco peat + 10% broken bricks). The results indicated that the maximum number of the female flower was produced by the application of higher doses of vermicompost than the control with ensuring the better yield of bitter gourd. This result was in agreement with the findings of Anuja and Archana (2011) and Namayandeh and Shirdareh (2015).

Effect of GA_3

Different plant growth regulators showed statistically significant variation in the number of female flowers (Table 6 and Appendix IX). The highest number of female flowers (25.44) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest number of female flowers (22.70) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that the maximum female flower in number was produced by the application of GA_3 compared to the control. The supported result was also observed by Ashrafuzzaman *et al.* (2010), Akter and Rahman (2013), and Nagamani *et al.* (2015).

Interaction effect of vermicompost and GA_3

The interaction effect between plant growth regulators and fertilizer management practices showed statistically significant variation in consideration of female flower in number (Table 7 and Appendix IX). Results indicated that the highest number of female flowers (27.93) was found from the treatment combination of V_2G_1 which was statistically similar to the treatment combination of V_1G_1. The lowest number of female flowers (20.50) was obtained from the treatment combination of V_0G_0 which was statistically similar to the treatment combination of V_0G_1. The results indicated that the combination of a higher rate of vermicompost and GA_3 ensures the increased female flower in number which helps to increase bitter gourd yield.

Table 6. Yield contributing parameters of bitter gourd as influenced by gibberellins on water surface of fish pond

Treatments	Yield contributing parameters					
	Days to 1st flowering	Number of male flowers	Number of female flowers	% fruit set	Fruit length (cm)	Fruit diameter (cm)
G_0	26.50	27.28	22.70	33.09	11.41	6.57
G_1	25.50	30.17	25.44	35.27	12.90	7.36
$LSD_{0.05}$	0.412	1.057	1.304	4.91	0.369	0.119
CV(%)	8.39	7.16	10.42	4.91	8.39	7.16

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

4.2.4 Percent fruit set (%)

Effect of vermicompost

In terms of male flower in number for different vermicompost doses, a statistically significant variation was recorded under the trial (Table 5 and Appendix IX). It was observed that the highest % fruit set (36.23) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) which was statistically identical with V_1 (30% vermicompost + 60% coco peat/pot + 10% broken bricks) whereas the lowest % fruit set (31.51%) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). The results indicated that the lowest % fruit set was produced in the control condition i.e. higher doses of vermicompost showed a higher level of % fruit set compared to control. Sundararasu (2017) also found similar results on the number of male flowers that supported the present findings of the study.

Effect of GA_3

Different levels of GA_3 showed a statistically significant variation in the number of male flowers (Table 6 and Appendix IX). Results revealed that the highest % fruit set (35.27) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest % fruit set (33.09) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that a minimum % fruit set was produced in control comparing with the application of GA_3. The supported result was also observed by Ghani *et al.* (2013) and Ashrafuzzaman *et al.* (2010).

Interaction effect of vermicompost and GA_3

The interaction effect of vermicompost and GA_3 application showed a statistically significant variation in consideration of % fruit set (Table 7 and Appendix IX). Results showed that the highest % fruit set (38.01) was found from the treatment combination of V_2G_1 which was significantly similar to V_1G_1. The lowest % fruit set (30.96%) was obtained from the treatment combination of V_0G_0 which was significantly similar to V_0G_1. The results on the number of male flowers obtained from the present study indicated that higher doses of vermicompost combination with GA_3 ensure the higher % fruit set of bitter gourd.

4.2.5 Fruit length (cm)

Effect of vermicompost

Significant influence was noted on fruit length affected by different vermicompost treatments (Table 5 and Appendix IX). It was found that the highest fruit length (13.61 cm) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) whereas the lowest fruit length (10.06 cm) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks).

Control treatment also showed better performance on fruit length because pond water also a source of plant nutrients. The results indicated that fruit length showed a gradually increasing trend in fruit length showed a gradually increasing trend with the increase of vermicompost. The present finding was also conformity with the findings of Nagar *et al.* (2017)

Effect of GA_3

Fruit length was varied significantly due to the GA_3 application (Table 6 and Appendix IX). Results showed that the highest fruit length (12.90 cm) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest fruit length (11.41 cm) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that the application of GA_3 ensures higher fruit length compared to control. Supported findings were also observed by Jyoti *et al.* (2016).

Interaction effect of vermicompost and GA_3

Significant variation was remarked as influenced by the interaction of vermicompost and GA_3 (Table 7 and Appendix IX). Results revealed that the highest fruit length (14.34 cm) was found from the treatment combination of V_2G_1 which was statistically identical with the treatment combination of V_1G_1. The lowest fruit length (9.55 cm) was obtained from the treatment combination of V_0G_0 which was significantly different from all other treatment combinations followed by V_0G_1. Experimental results indicated that a higher rate of vermicompost integration with GA_3 application makes sure increased fruit length compared to a lower level or no vermicompost and GA_3 association.

4.2.6 Fruit diameter (cm)

Effect of vermicompost

Statistically, significant variation was recorded under the trial for fruit diameter for different vermicompost levels (Table 5 and Appendix IX). Fruit diameter showed a gradually increasing trend with increasing vermicompost application comparing the control. Results indicated that the highest fruit diameter (7.81 cm) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) which were significantly different from others. The lowest fruit diameter (5.80 cm) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). This result was also in agreement with the findings of Thriveni *et al.* (2015), Namayandeh and Shirdareh (2015), Nagar *et al.* (2017), and Ashrafuzzaman et al. (2010).

Effect of GA_3

GA_3 application showed a statistically significant variation on fruit diameter compared to control (Table 6 and Appendix IX). It was observed that the highest fruit diameter (7.36 cm) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest fruit diameter (6.57 cm) was obtained from the control treatment G_0 (0 ppm GA_3). This result indicated that GA_3 is better than a control for increasing fruit diameter. The supported result was also observed by Jyoti *et al.* (2016) and Ashrafuzzaman *et al.* (2010).

Table 7. Yield contributing parameters of bitter gourd as influenced by vermicompost and gibberellins on water surface of fish pond

Treatments	Yield contributing parameters					
	Days to 1st flowering	Number of male flowers	Number of female flowers	% fruit set	Fruit length (cm)	Fruit diameter (cm)
V_0G_0	27.50 a	25.20 d	20.50 e	30.96 d	9.55 e	5.41 f
V_0G_1	27.00 a	27.40 c	22.20 de	32.06 cd	10.58 d	6.19 e
V_1G_0	26.00 b	27.80 c	22.85 cd	33.86 bc	11.80 c	6.88 d
V_1G_1	25.50 b	30.60 b	26.20 ab	35.74 ab	13.79 a	7.67 b
V_2G_0	26.00 b	28.85 c	24.75 bc	34.45 bc	12.89 b	7.42 c
V_2G_1	24.00 c	32.50 a	27.93 a	38.01 a	14.34 a	8.21 a
$LSD_{0.05}$	0.9375	1.628	2.009	2.401	0.8290	0.2151
CV(%)	8.39	7.16	10.42	4.91	8.39	7.16

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

Interaction effect of vermicompost and GA_3

Interaction effect between vermicompost and GA_3 showed statistically significant variation in consideration of fruit diameter (Table 7 and Appendix IX). Results revealed that the highest fruit diameter (8.21 cm) was found from the treatment combination of V_2G_1 which was significantly different from all other treatment combinations followed by V_0G_1. The lowest fruit diameter (5.41 cm) was obtained from the treatment combination of V_0G_0 which was also significantly different from all other treatment combinations. The results indicated that increased fruit diameter is ensured with higher levels of vermicompost interact with the GA_3 application.

4.3 Yield parameters

4.3.1 Number of fruits pot^{-1}

Effect of vermicompost

Different levels of vermicompost showed a statistically significant variation on the number of fruits pot^{-1} (Table 8 and Appendix X). Results showed that the highest number of fruits pot^{-1} (20.72) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) whereas the lowest number of fruits pot^{-1} (15.03) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks) and treatment V_1 (30% vermicompost + 60% coco peat/pot + 10% broken bricks) showed the intermediate result. The results indicated that the maximum number of fruits pot^{-1} was produced by the application of vermicompost than the control with ensuring the better yield of bitter gourd. This result was in agreement with the findings of Thriveni *et al.* (2015), Nagar *et al.* (2017), and Reddy and Rao (2004).

Effect of GA_3

Different GA_3 levels showed a statistically significant variation in the number of fruits per plant (Table 9 and Appendix X). It was found that the highest number of fruits pot^{-1} (19.72) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest number of fruits pot^{-1} (16.59) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that the application of GA_3 maximizes the number of fruits pot^{-1}. The supported result was also observed by Ashrafuzzaman *et al.* (2010) and David *et al.* (2005).

Interaction effect of vermicompost and GA_3

The interaction effect of vermicompost and GA_3 showed a statistically significant variation in consideration of fruits per plant in number (Table 10 and Appendix X). Results showed that the highest number of fruits pot^{-1} (22.97) was found from the treatment combination of V_2G_1 which was significantly different from all other treatment combinations followed by V_1G_1. The lowest number of fruits pot^{-1} (14.15) was obtained from the treatment combination of V_0G_0 followed by V_0G_1. The results indicated that the combination of vermicompost and GA_3 ensures the optimum condition for the growth and development of bitter gourd and the ultimate result is the maximum number of fruits pot^{-1}.

4.3.2 Single fruit weight (g)

Effect of vermicompost

The recorded data on a single fruit weight was significantly influenced by different vermicompost levels (Table 8 and Appendix X). The highest single fruit weight (73.48 g) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) followed by V_1 (30% vermicompost + 60% coco peat/pot + 10% broken bricks) whereas the lowest single fruit weight (57.02 g) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). This result indicated that higher single fruit weight was responsible for higher rated of vermicompost. The present finding was also conformity with the findings of Thriveni *et al.* (2015), Nagar *et al.* (2017), and Shree *et al.* (2018).

Effect of GA_3

The recorded data on a single fruit weight was significantly influenced by GA_3 applications (Table 9 and Appendix X). The highest single fruit weight (69.47 g) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest single fruit weight (62.76 g) was obtained from the control treatment G_0 (0 ppm GA_3). This

result indicated that higher single fruit weight was found with GA_3 compared to control. The supported finding was also observed by Ashrafuzzaman *et al.* (2010) and Hossain *et al.* (2006).

Interaction effect of vermicompost and GA_3

Remarkable variation was identified on single fruit weight due to the interaction effect of vermicompost and GA_3 (Table 10 and Appendix X). It was noted that the highest single fruit weight (77.60 g) was found from the treatment combination of V_2G_1 which was significantly different from all other treatment combinations followed by V_1G_1. The lowest single fruit weight (54.80 g) was obtained from the treatment combination of V_0G_0 followed by V_0G_1. These results indicated that a combination of higher doses of vermicompost with GA_3 resulted in maximum single fruit weight compared to no application of vermicompost and GA_3.

4.3.3 Fruit weight pot^{-1} (g)

Effect of vermicompost

Different levels of vermicompost showed a statistically significant variation on fruit weight pot^{-1} (Table 8 and Appendix X). Results signified that the highest fruit weight pot^{-1} (1532 g) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) followed by V_1 (30% vermicompost + 60% coco peat/pot + 10% broken bricks). The lowest fruit weight pot^{-1} (861.60 g) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). The results indicated that maximum fruit weight pot^{-1} was produced by the higher levels of application of vermicompost than that of control. This result was also in agreement with the findings of Thriveni *et al.* (2015), Nagar *et al.* (2017), and Sundararasu (2017).

Effect of GA_3

Different GA_3 levels showed a statistically significant difference on fruit weight pot^{-1} (Table 9 and Appendix X). It was found that the highest fruit weight pot^{-1} (1393.02 g) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest fruit weight pot^{-1} (1052.36 g) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that the application of GA_3 maximizes the fruit weight pot^{-1} compared to control. The supported result was also observed by Jyoti *et al.* (2016) and Ashrafuzzaman *et al.* (2010).

Interaction effect of vermicompost and GA_3

The interaction effect of vermicompost and GA_3 showed a statistically significant variation in consideration of fruit weight pot^{-1} (Table 10 and Appendix X). Results showed that the highest fruit weight pot^{-1} (1783 g) was found from the treatment combination of V_2G_1 which was significantly different from all other treatment combinations followed by V_1G_1. The lowest fruit weight pot^{-1} (945.60 g) was obtained from the treatment combination of V_0G_0 followed by V_0G_1. The results indicated that the combination of vermicompost and GA_3 makes certain the optimum condition for the growth and development of bitter gourd and the ultimate result is maximum fruit weight pot^{-1}.

Table 8. Yield parameters of bitter gourd as influenced by vermicompost on water surface of fish pond

Treatments	Yield parameters			
	Number of fruits pot^{-1}	Single fruit weight (g)	Fruit weight pot^{-1} (g)	Yield ha^{-1} (t)
V_0	15.03 c	57.02 c	861.60 c	11.97 c
V_1	18.73 b	67.85 b	1274.00 b	17.70 b
V_2	20.72 a	73.48 a	1532.00 a	21.28 a
$LSD_{0.05}$	0.7902	2.591	98.15	0.6085
CV(%)	8.39	7.16	10.42	5.85

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

Table 9. Yield parameters of bitter gourd as influenced by gibberellins on water surface of fish pond

Treatments	Yield parameters			
	Number of fruits pot^{-1}	Single fruit weight (g)	Fruit weight pot^{-1} (g)	Yield ha^{-1} (t)
G_0	16.59	62.76	1052.36	14.62
G_1	19.72	69.47	1393.02	19.35
$LSD_{0.05}$	1.245	2.372	1232.65	1.032
CV(%)	8.39	7.16	10.42	5.85

G_0 = 0 ppm (Control), G_1 = 40 ppm

4.3.4 Fruit yield (t ha^{-1})

Effect of vermicompost

Different levels of vermicompost showed a statistically significant variation on fruit yield ha^{-1} (Table 8 and Appendix X). Results signified that the highest fruit yield ha^{-1} (21.28) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) followed by V_1 (30% vermicompost + 60%

coco peat/pot + 10% broken bricks). The lowest fruit yield ha^{-1} (11.97 t) was obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). The results indicated that maximum fruit yield ha^{-1} was produced on account of higher single fruit weight and fruit weight pot^{-1} that was also achieved from the same treatment. Maximum yield was obtained from V_2 treatment because yield contributing parameters were also achieved from this treatment. Again, control treatment also showed comparatively better results on different yields and yield contributing parameters which might be due to the cause of pond water which was also a source of plant nutrients, and bitter gourd root system was associated with pond water nutrient uptake was done by the root system. Results also indicated that no vermicompost showed lower bitter gourd yield. This result was also in agreement with the findings of Thriveni *et al.* (2015), Nagar *et al.* (2017), and Sundararasu (2017).

Effect of GA_3

Different GA_3 levels showed a statistically significant difference in fruit yield ha^{-1} (Table 9 and Appendix X). It was found that the highest fruit yield ha^{-1} (19.35 t) was found from the treatment G_1 (40 ppm GA_3) whereas the lowest yield ha^{-1} (14.62 t) was obtained from the control treatment G_0 (0 ppm GA_3). The results indicated that the application of GA_3 maximizes the fruit yield ha^{-11} compared to control. The supported result was also observed by Jyoti *et al.* (2016) and Ashrafuzzaman *et al.* (2010).

Interaction effect of vermicompost and GA_3

The interaction effect of vermicompost and GA_3 showed a statistically significant variation in consideration of fruit yield ha^{-1} (Table 10 and Appendix X). Results showed that the highest fruit yield ha^{-1} (24.76 t) was found from the treatment combination of V_2G_1 which was significantly different from all other treatment combinations followed by V_1G_1. The lowest fruit yield ha^{-1} (10.80 t) was obtained

from the treatment combination of V_0G_0 followed by V_0G_1. The results indicated that the combination of vermicompost and GA_3 from the treatment combination of V_2G_1 made the optimum condition in the field for the growth and development of bitter gourd and the ultimate result is maximum fruit yield ha^{-1}.

Table 10. Yield parameters of bitter gourd as influenced by vermicompost and gibberellins on water surface of fish pond

Treatments	Yield parameters			
	Number of fruits pot^{-1}	Single fruit weight (g)	Fruit weight pot^{-1} (g)	Yield ha^{-1} (t)
V_0G_0	14.15 f	54.80 e	777.70 f	10.80 f
V_0G_1	15.90 e	59.24 d	945.60 e	13.13 e
V_1G_0	17.15 d	64.13 c	1098.00 d	15.25 d
V_1G_1	20.30 b	71.57 b	1451.00 b	20.15 b
V_2G_0	18.47 c	69.35 b	1282.00 c	17.80 c
V_2G_1	22.97 a	77.60 a	1783.00 a	24.76 a
$LSD_{0.05}$	1.118	3.664	138.80	0.8606
CV(%)	8.39	7.16	10.42	5.85

V_0 = 90% Coco Peat (Control) + 10% broken bricks, V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks, V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks

G_0 = 0 ppm GA_3 (Control), G_1 = 40 ppm GA_3

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from March to June 2019 to determine the response of vermicompost and gibberellin on bitter gourd production in the water surface of the fish pond. The experiment considered of two factors, Factor A: vermicompost (3 levels) *viz.* (i) V_0 = 90% coco peat + 10% broken bricks (control), (ii) V_1 = 30% vermicompost + 60% coco peat/pot + 10% broken bricks and (iii) V_2 = 60% vermicompost + 30% coco peat/pot + 10% broken bricks and Factor B: GA_3 (2 levels) *viz.* (i) G_0 = 0 ppm GA_3 (Control) and (ii) G_1 = 40 ppm GA_3. There were on the whole 6 (3×2) treatment combinations. The experiment was laid out in the two factors Completely Randomized Design (CRD) with three replications. After the emergence of seedlings, various intercultural operations were accomplished for better growth and development of the plant. Data were collected in respect of the bitter gourd growth characters and yield and yield contributing characters. The data obtained for different characters were statistically analyzed to find out the significance of the difference between the treatments.

Considering the vermicompost application, all the studied parameters showed a significant difference among the treatments. Regarding growth parameters, the highest vine length (43.05, 93.10, and 128.30 cm at 25, 40, and 60 DAT, respectively), number of leaves plant^{-1} (79.50117.30 and 129.30 at 25, 40, and 60 DAT, respectively), number of branches plant^{-1} (3.81, 9.25 and 13.17 at 25, 40 and 60 DAT, respectively) and leaf area at 50 DAT (69.37 cm^2) were achieved from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) whereas the lowest vine length (29.98, 74.11 and 100.70 cm at 25, 40 and 60

DAT, respectively), number of leaves plant^{-1} (38.73, 73.33 and 86.67 at 25, 40 and 60 DAT, respectively), number of branches plant^{-1} (2.43, 5.52 and 10.11 at 25, 40 and 60 DAT, respectively) and leaf area at 50 DAT (48.38 cm^2) were obtained from the control treatment V_0 (90% coco peat + 10% broken bricks). Regarding yield and yield contributing parameters, the lowest days to 1st flowering (25.00) was found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) and control treatment V_0 (90% coco peat + 10% broken bricks) showed highest days to 1st flowering (27.25). Again, the highest number of male flowers (30.67), number of female flowers (26.34), % fruit set (36.23%), fruit length (13.61 cm), fruit diameter (7.81 cm), number of fruits pot^{-1} (20.72), single fruit weight (73.48 g), fruit weight pot^{-1} (1532 g) and fruit yield ha^{-1} (21.58) were found from the treatment V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) whereas the lowest number of male flowers (26.30), number of female flowers (21.35), % fruit set (31.51%), fruit length (10.06 cm), fruit diameter (5.80 cm), number of fruits pot^{-1} (15.03), single fruit weight (57.02 g), fruit weight pot^{-1} (861.60 g) and fruit yield ha^{-1} (11.97 t) were obtained from the control treatment V_0 (90% coco peat + 10% broken bricks).

In terms of GA_3 application, all the studied parameters showed significant distinction among the treatments. Regarding growth parameters, the highest vine length (40.13, 90.50, and 124.25 cm at 25, 40, and 60 DAT, respectively), number of leaves plant^{-1} (69.22, 109.11, and 120.22 at 25, 40, and 60 DAT, respectively), number of branches plant^{-1} (3.52, 8.38 and 12.49 at 25, 40 and 60 DAT, respectively) and leaf area at 50 DAT (65.28 cm^2) were found from the treatment G_1 (40 ppm GA_3) whereas the control treatment G_0 (0 ppm GA_3) gave lowest vine length (33.38, 81.05 and 110.43 cm at 25, 40 and 60 DAT, respectively), number of leaves plant^{-1} (54.89, 87.22 and 102.33 at 25, 40 and 60 DAT, respectively), number of branches plant^{-1} (2.90, 7.05 and 11.11 at 25, 40 and 60 DAT, respectively) and leaf area at 50 DAT (54.09 cm^2) was obtained from the control

treatment G_0 (0 ppm GA_3). Regarding yield and yield contributing parameters, the lowest days to 1st flowering (25.50) was found from the treatment G_1 (40 ppm GA_3) and the highest days to 1st flowering (26.50) was obtained from the control treatment G_0 (0 ppm GA_3). Again, the highest number of male flowers (30.17), number of female flowers (25.44), % fruit set (35.27), fruit length (12.90 cm), fruit diameter (7.36 cm), number of fruits pot^{-1} (19.72), single fruit weight (69.47 g), fruit weight pot^{-1} (1393.02 g) and fruit yield ha^{-1} (19.35 t) were found from the treatment G_1 (40 ppm GA_3) whereas the lowest number of male flowers (27.28), number of female flowers (22.70), % fruit set (33.09%), fruit length (11.41 cm), fruit diameter (6.57 cm), number of fruits pot^{-1} (16.59), single fruit weight (62.76 g), fruit weight pot^{-1} (1052.36 g) and fruit yield ha^{-1} (14.62 t) were obtained from the control treatment G_0 (0 ppm GA_3)

Considering the interaction effect of vermicompost and GA_3 application, all the studied parameters showed significant variation among the treatments. Concerning growth parameters, the highest vine length (46.50, 98.18 and 136.60 cm at 25, 40, and 60 DAT, respectively), number of leaves $plant^{-1}$ (84.67, 130.70, and 139.00 at 25, 40, and 60 DAT, respectively), number of branches $plant^{-1}$ (4.06, 10.15 and 14.14 at 25, 40 and 60 DAT, respectively) and leaf area at 50 DAT (77.45 cm^2) were observed from the treatment combination of V_2G_1 whereas the lowest vine length (28.65, 69.02 and 94.67 cm at 25, 40 and 60 DAT, respectively), number of leaves $plant^{-1}$ (33.67, 65.00 and 80.00 at 25, 40 and 60 DAT, respectively), number of branches $plant^{-1}$ (2.10, 4.94 and 9.50 at 25, 40 and 60 DAT, respectively) and leaf area at 50 DAT (45.50 cm^2) was obtained from the treatment combination of V_0G_0. Under the consideration of yield and yield contributing parameters, the lowest days to 1st flowering (24.00) was found from the treatment combination of V_2G_1 where the highest (27.50) was obtained from V_0G_0. But the highest number of male flowers (32.50), number of female flowers (27.93), highest % fruit set (38.01%), fruit length (14.34 cm), fruit diameter (8.21 cm),

number of fruits pot^{-1} (22.97), single fruit weight (77.60 g), fruit weight pot^{-1} (1783 g) and fruit yield ha^{-1} (24.76 t) were achieved from the treatment combination of V_2G_1 whereas the lowest number of male flowers (25.20), number of female flowers (20.50), % fruit set (30.96%), fruit length (9.55 cm), fruit diameter (5.41 cm), number of fruits pot^{-1} (14.15), single fruit weight (54.80 g), fruit weight pot^{-1} (945.60 g) and fruit yield ha^{-1} (10.80 t) were obtained from the treatment combination of V_0G_0.

From the study, it might be concluded that both vermicompost and plant growth regulator (GA_3) had a positive on the growth parameters, yield attributes, and yield of bitter gourd. Among the three treatments of vermicompost management, significantly the highest positive effect was recorded from the plant treated with V_2 (60% vermicompost + 30% coco peat/pot + 10% broken bricks) compared to control V_0 (90% coco peat + 10% broken bricks). Again, among the two treatments of GA_3, the highest positive result was obtained from G_1 (40 ppm GA_3) compared to control G_1 (40 ppm GA_3). In terms of the interaction effect of vermicompost and GA_3, the treatment combination of V_2G_1 showed the best results on growth, yield attributes, and yield parameters of bitter gourd. So, this treatment combination (V_2G_1) can be treated as the best among all the treatment combinations. Whereas V_0G_0 showed lower performance due to lack of vermicompost and gibberellin. On the other hand, V_0G_0 showed some growth and yield due to the presence of nitrogen and phosphorus in pond water. Hence, if there is no available vermicompost and GA_3, V_0G_0 treatment can be followed.

REFERENCES

Anonymous. (2002). Statistical Pocket Book of Bangladesh. (2002). Bangladesh Bureau of Statistics. Government of the Peoples' Republic of Bangladesh, Dhaka, Bangladesh, p. 184.

Anuja, S. and Archana, S. (2011). Effect of soil and foliar application of organic nutrients on flowering and fruit-set of bittergourd cv. Long Green. *The Asian J. Hort*., **6**(2): 361-364.

Bangladesh Meteorological Department (March-June, 2019). Data recorded on air temperature, relative humidity and rainfall. Climate division, Agargaon, Dhaka-1212.

Biradar, G. Nawalagatti, C.M. and Pavithra, C.B. (2012). A study on the effect of plant growth regulators on yield, biochemical and physiological characters of bitter gourd *(Momordica charantia* L). International Conference on Agricultural & Horticultural Sciences. Hyderabad International Convention Centre, India.

Bisaria, A. K. (1974). Sex expression and fruit development in cucumber as effect by Gibberellins. *Indian J. Hort*., **16**: 233-235.

Dalai, S., Singh, M.K., Singh, K.V., Kumar, M., Malik, S., and Kumar, V. (2015). Effect of Foliar Application of GA3and NAA on Growth, Flower-Ing Yield and Yield Attributes of Cucumber (*Cucumis sativus* L.). *Annals Hort*., **8**(2), 181-194.

Das, R., Mandal, A.R., AnujaPriya, S.P., Das, J. and Kabiraj, R. (2015). Evaluation of intergrated nutrient management on the performance of Bottle gourd. *J. Appl. and Natural Sci*., **7**(1): 18 – 25.

David, I.S., Titen, T.S. and Ramesh. S.R. (2005). Effect of growth regulators on yield and quality attributes in tomato *(Lycopersicon esculentum). Adv. Plant Sci.,* **10**(2): 29-31.

Edwards, C.A. and Burrows, I. (1988). The potential of earthworm composts as plant growth media. In Earthworms in Environmental and Waste Management Ed. C. A., Neuhauser, SPB Academic Publ. b.v. The Netherlands. 211-220.

Follet, R., Donahue, R. and Murphy, L. (1981). Soil and Soil Amendments. Prentice hall: Inc., New Jersey.

Gajjela, S., Chatterjee, R., Subba , S., and Sen, A. (2018). Prospect of liquid organic manure on organic bitter gourd cultivation. *J. Pharma. Phytochem*., **7**(6): 189-193.

Gedam, V.M., Patil, R.B., Suryawanswhi, Y.B. and Mate, S.N. (1998). Effect of plant growth regulators and boron of flowering, fruiting and seed yield in bitter gourd. *Seed Res*., **26**(1): 97-100.

Geeta, B., Chetti, M.B. and Navalgatti, C.M. (2014). Effect of plant growth regulators on leaf biochemical characters and fruit yield components of bittergourd *(Momordica charantia* L.) cvs. MHBI-15 and Chaman Plus. *J. Hortl. Sci.*, **9**(1): 43-47.

Ghani, M.A., Amjad, M., Iqbal, Q., Nawaz, A., Ahmad , T., Hafeez, O.B.A. and Abbas, M. (2013). Efficacy of Plant Growth Regulators on Sex Expression, Earliness and Yield Components in Bitter Gourd. *Pak. J. Life Soc. Sci*. **11**(3): 218-224.

Gomez, K.H. and Gomez, A.A. (1984). "Statistical Procedures for Agricultural Research". Inter Science Publication, Jhon wiley and Sono, New York. pp. 680.

Gopalkrishnan, P.K. and Choudhury, B. (1978). Effect of plant regulator sprays on modification of sex, fruit set and development in watermelon (*Citrullus lanatus*). *Indian J. Hort*., 35: 235-241

Hammad, H.M., Khaliq, A., Ahmad, A. and Lagharei, K. (2011). Influence of different organic manures on wheat productivity. *Int. J. Agric. Biol.*, **13**(1): 137-140.

Hidalgo, P. (1999). Earthworm castings increase germination rate and seedling development of cucumber. Mississippi and Forestry Experiment Station, Research Report, 22 No. 6.

Hidayatullah, T.M., Farooq, M., Khokhar, M.A., and Hussain, S.I. (2012). Plant growth regulators affecting sex expression of bottle gourd (*Lagenariasiceraria molina*) plants. *Pakistan J. Agric. Res*., **25**(1): 106-111.

Hossain, D., Karim, M. A., Pramanik, M. H. R. and Rahman, A. S. (2006). Effect of Gibberellic Acid (GA_3) on Flowering and Fruit Development of Bitter Gourd

Islam, M.S. (1995). Seed production studies on bitter gourd (*Momordica charantia* L.) Ph. D Thesis, CLSU, Munoz, Nueva Ecija, the Philippines.

John, B. and Prabha, M.L. (2013). Effect of vermicompost on the growth and yield of *Capsicum annum*. *Int. J. Pharma Bio-Sci.*, **4**(3): 1284-1290.

Jyoti, S., Patel, N.B. and Patel, J.B. (2016). Effect of growth regulators and stages of spray on seed yield and seed quality parameters of ridge gourd [*Luffa acutangula* (Roxb) L.]. *J. App. Nat. Sci.*, **8**(3): 1551 - 1555.

Meena, O., Khafi, H.R., Seikh, M.A., Mehta, A. C. and Davda, B.K. (2007). Effect of Vermicompost and Nitrogen on Content, Uptake and Yield of Rabi Maize. *J. Crop. Res.*, **33**(1, 2 & 3): 53-54.

Mia, B. M., Islam, M. S., Miah, M. Y., Das, M. R. and Khan, H. I. (2014). Flower synchrony, growth and yield enhancement of small type bitter gourd (*Momordica charantia* L.) through plant growth regulators and NPK fertilization. *Pak. J. Biol. Sci.*, **17**(3): 408-413.

Nagamani, S., Basu, S., Singh, S., Lal, S.K, Behera, T.K., Chakrabarty, S.K. and Talukdar, A. (2015). Effect of plant growth regulators on sex expression, fruit setting, seed yield and quality in the parental lines for hybrid seed production in bitter gourd (*Momordica charantia*). *Indian J. Agric. Sci.*, **85**(9): 1185–91, September 2015/Article.

Nagar, M., Soni, A.K. and Sarolia, D.K. (2017). Effect of Organic Manures and Different Levels of NPK on Growth and Yield of Bottle Gourd [Lagenaria siceraria (Mol.) Standl.] *Int. J. Curr. Microbiol. Appl. Sci.*, **6**(5): 1776-1780.

Namayandeh, A. and Shirdareh, E. (2015). The effect of compost, vermicompost and urea fertilizers on operation and operation facture on Pumpkin Msmayy (*Cucurbita pepo* L.) *Cumhuriyet Univ. Sci. J. (CSJ)*, **36**(3): 1300-1949.

Prakash, G.F. (1974). Effect of photoperiod, alpha-NAA and MH on sex expression and ratio in bitter gourd (*Momordica charantia* L.). *Plant. Sci.*, 6: 553.

Rana, M.K. (2004). Organic farming: An eco-friendly vegetable production system. *Haryana J. Hort. Sci.*, **33**(1&2):87-97.

Reddy, P.K and Rao, P.V. (2004). Growth and yield of bitter gourd (*Momordica charantia* L.) as influenced by vermicompost and nitrogen management practices. *Indian J. Res.*, **32**(3): 15-20

Sandra, N., kumar Lal, S., Chakrabarty, S.K. and Talukdar, A. (2015). Effect of plant growth regulators on sex expression, fruit setting, seed yield and quality in the parental lines for hybrid seed production in bitter gourd *(Momordica charantia). Indian J. Agric. Sci.*, **85**(9): 1185-91.

Sangeeta, S., Champa, L.R., Ahmad, F., Singh, V.K., Kumari, R. and Kumari, A. (2018). Effect of organic and inorganic fertilizers on growth, yieldand quality attributes of Hybrid Bitter gourd (Momordica charantia L.). Int. J. Curr. Microbiol. *App. Sci.*, **7**(4): 2256-2266.

Shahzad, A. (2012). Morpho-physiological effect of Gibberellic Acid on bitter gourd. Botany, ISBN-13: 978-3-8484-2436-8. Lambert Academic Publisher's.

Shantappa, T., Shekhargouda, M. Meharwade, M.N. and Deshpande, V.K. (2007). Seed yield and quality as influenced by plant growth regulators and stages of spray in bitter gourd cv. Coimbatore long. *Seed Res.*, **35**(1): 11-16.

Shi-wei, Z. and Fu-zhen, H. (1991). The nitrogen uptake efficiency from 15N labelled chemical fertilizer in the presence of earthworm manure (cast). In: Veeresh, G.K., D. Rajagopal and C.A. Viraktamath (eds) Advances in Management and Conservation of Soil Fauna. Oxford and IBH publishing Co., New Delhi, Bombay, pp. 539-542.

Shree, S., Regar, C.L., Ahmad, F., Singh, V.K., Kumari, R. and Kumari, A. (2018). Effect of Organic and Inorganic Fertilizers on Growth, Yield and Quality Attributes of Hybrid bitter gourd (*Momordica charantia* L.). *Int. J. Curr. Microbiol. App. Sci.* **7**(4): 2256-2266.

Sundararasu, K. (2017). Effect of vermicompost and vermiwash on growth and Yield of bottle gourd (*Lagenaria siceraria*). *Int. J. Appl. Pure Sci. Agric. (IJAPSA)*. **3**(10): 19-24.

Sureshkumar, R., Deepa, S., Rajkumar, M. and Sendhilnathan, R. (2019). Effect of organic nutrients on certain growth and yield characters of bitter gourd (*Momordica charantia* L.) ecotype "Mithipagal". *Plant Archives*. **19**(1): 1013-1016.

Thriveni, V., Mishra, H.N., Pattanayak, S.K., Sahoo, G.S. and Thomson, T. (2015). Effect of inorganic, organic fertilizers and biofertilizers on growth, flowering, yield and quality attributes of bitter gourd, *Momordica charantia* L. *Int. J. Farm Sci*., **5**(1): 24-29.

Tomar, I. S. and S. R. Ramgiry. (1997). Effect of growth regulators on yield and yield attributes in tomato (*Lycopersicon esculentum* Mill.). *Adv. plant Sci*., **10**(2): 29-31.

Wang, Q.M. (2001). Effect of CPPU on growth and endogenous phytohormone contents of balsmpear (*Momordica charantia* L.) fruit. China Journal of Zhejiang Univ. *Agric. Life Sci*. **27**: 5, 513-517.

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

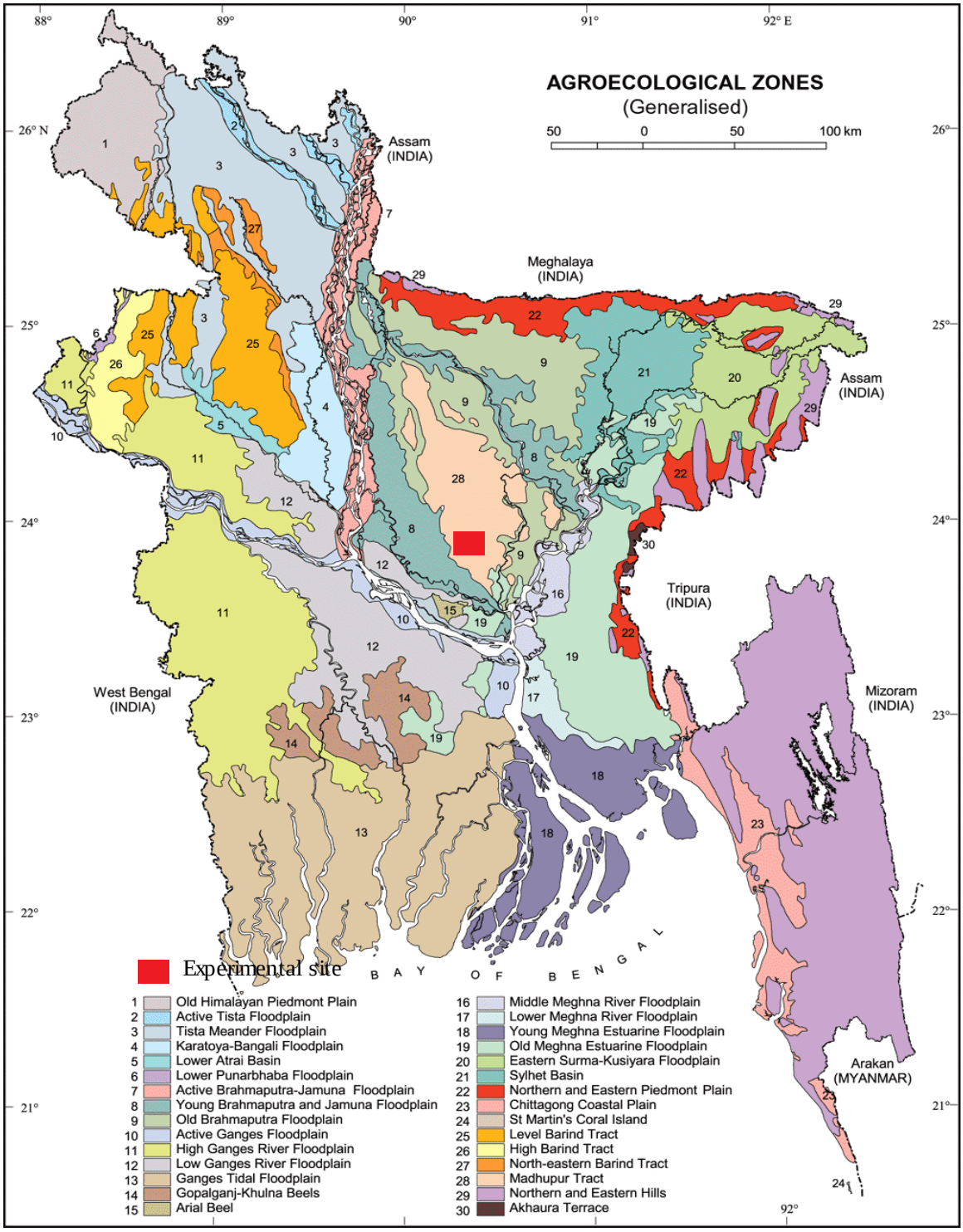

Figure 9. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from March to June 2019.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2019	March	35.20	21.00	28.10	52.44	20.4
2019	April	34.70	24.60	29.65	65.40	165.0
2019	May	32.64	23.85	28.25	68.30	182.2
2019	June	27.40	23.44	25.42	71.28	190

Source: Bangladesh Meteorological Department (March-June, 2019).

Appendix III. Layout of the experiment

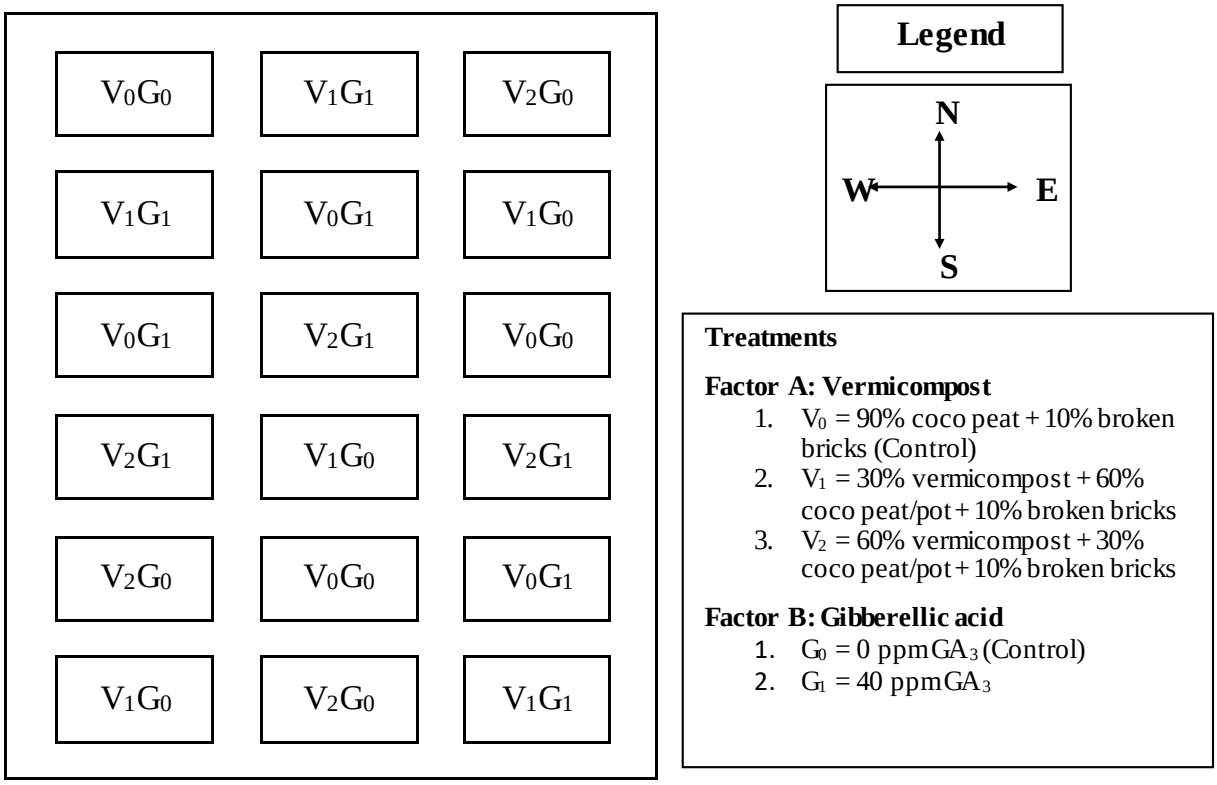

Figure 10. Layout of the experimental

Appendix IV. Physical and chemical properties of pond water

Item	**Characteristics**
Temperature	29°C
pH	7.6
Dissolved oxygen (DO)	6.40 mg L^{-1}
Ammonia (NH_3)	0.03 mg L^{-1}
Phosphate (PO_4)	0.74 mg L^{-1}
Nitrate (NO_3)	0.07 mg L^{-1}

Appendix V. Vine length of bitter gourd as influenced by interaction effect of vermicompost and gibberellins on water surface of fish pond

Sources of variation	Degrees of freedom	Mean square of vine length		
		25 DAT	40 DAT	60 DAT
Factor A	2	171.681*	417.083*	855.798*
Factor B	1	136.688	268.191*	572.839*
AB	2	16.218*	1.555**	5.931*
Error	12	1.740	1.217	1.646

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Number of leaves $plant^{-1}$ of bitter gourd as influenced by interaction effect of vermicompost and gibberellins on water surface of fish pond

Sources of variation	Degrees of freedom	Mean square of number of leaves $plant^{-1}$		
		25 DAT	40 DAT	60 DAT
Factor A	2	2630.89*	3048.50*	2924.06*
Factor B	1	924.50*	2156.06*	1440.05*
AB	2	72.00**	37.722*	24.38*
Error	12	2.40	6.50	8.39

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Number of branches plant^{-1} of bitter gourd as influenced by interaction effect of vermicompost and gibberellins on water surface of fish pond

Sources of variation	Degrees of freedom	Mean square of number of branches plant^{-1}		
		25 DAT	40 DAT	60 DAT
Factor A	2	2.013*	15.193*	9.637*
Factor B	1	1.153	5.307*	5.741**
AB	2	0.010**	0.170**	0.248**
Error	12	0.006	0.023	0.025

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Leaf area of bitter gourd as influenced by interaction effect of vermicompost and gibberellins on water surface of fish pond

Sources of variation	Degrees of freedom	Mean square of leaf area at 50 DAT
Factor A	2	448.29*
Factor B	1	375.87*
AB	2	27.174*
Error	12	2.244

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix IX. Yield contributing parameters of bitter gourd as influenced by vermicompost and gibberellins on water surface of fish pond

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters					
		Days to 1st flowering	Number of male flowers	Number of female flowers	% fruit set	Fruit length	Fruit diameter
Factor A	2	5.250*	19.818*	25.517*	35.15*	13.82*	4.343*
Factor B	1	3.000*	24.941*	22.578*	21.34*	6.660*	1.849*
AB	2	0.750*	0.531*	0.824*	2.381**	0.232*	0.001**
Error	12	0.133	0.401	0.611	2.821	0.104	0.007

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix X. Yield parameters of bitter gourd as influenced by interaction effect of vermicompost and gibberellins on water surface of fish pond

Sources of variation	Degrees of freedom	Mean square of yield parameters			
		Number of fruits pot^{-1}	Single fruit weight	Fruit weight pot^{-1}	Yield ha^{-1}
Factor A	2	4575.798*	279.928*	33.376*	132.38*
Factor B	1	3481.075*	135.005*	29.485*	100.725*
AB	2	278.101*	4.025**	1.898**	8.049**
Error	12	29.019	2.032	0.189	0.234

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix XI. Preparation of raft

Plate 1. Raft preparation with cork sheet and bamboo slit

Appendix XII. Vine management

Plate 2. Vine management with plastic net,