PERFORMANCE OF TOMATO IN RESPONSE TO GROWING MEDIA AND PROBIOTICS IN THE POND FLOATING SYSTEM

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PERFORMANCE OF TOMATO IN RESPONSE TO GROWING MEDIA AND PROBIOTICS IN THE POND FLOATING SYSTEM

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CERTIFICATE

*This is to certify that the thesis entitled **"PERFORMANCE OF TOMATO IN RESPONSE TO GROWING MEDIA AND PROBIOTICS IN THE POND FLOATING SYSTEM"** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **HORTICULTURE,** embodies the results of a piece of bonafide research work carried out by **SURAVI PAUL,** Registration No. **14-5984** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.*

I further certify that such help or sources of information as has been availed of during the course of this investigation have been duly acknowledged.

Date: June, 2021
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TO

MY BELOVED PARENTS

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PERFORMANCE OF TOMATO IN RESPONSE TO GROWING MEDIA AND PROBIOTICS IN THE POND FLOATING SYSTEM

ABSTRACT

A pot experiment was conducted during October 2019 to January 2020 to evaluate the performance of tomato in response to growing media and probiotics in the pond of Sher-e-Bangla Agricultural University, Dhaka. The experiment was laid out in Completely Randomized Design (CRD) having two factors with three replications. Factor A: Growing Media (3 levels) i.e. G_1= 10% khoa + 90% coco peat (control), G_2= 10% khoa + 60% coco peat + 30% vermicompost, G_3= 10% khoa + 45% coco peat + 45% vermicompost and Factor B: 3 levels of probiotic i.e. P_0= 0 gm probiotic(control), P_1= 5 gm probiotic/pot, P_2= 10 gm probiotic/pot. Result indicated that, almost all of the parameters varied significantly. The highest plant height (95.24cm), maximum number of fruits (29.67) and highest fruit yield (1.84 kg) per plant were obtained from G_3 treatment, whereas it was the lowest in G_1 treatment. Considering the probiotic performance, the highest plant height (89.69 cm), maximum number of fruits (27.45) and highest fruit yield (1.65kg) per plant were obtained from P_2 treatment, while the lowest result was noted in P_0 treatment. It was observed that, the treatment combination G_3P_2 gave the best performance in terms of growth and yield parameters compared to G_1P_0. So, it can be concluded that, growing media with 10% khoa + 45% coco peat + 45% vermicompost and 10gm probiotic was effective for better tomato production in the pond floating system.`

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BARI	=	Bangladesh Agricultural Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAT	=	Days After Transplanting
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
gm	=	gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
^{o}C	=	Degree Celsius
%	=	Percentage

CHAPTER I

INTRODUCTION

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INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is an herbaceous annual crop in the family Solanaceae grown for its edible fruit. The plant can be erect with short stems or vine-like with long spreading stems. It is one of the highest grown vegetable all over the world including Bangladesh (Ahmad, 2012). Tomato originated in South America and was brought to Europe by the Spaniards in the sixteenth century following their colonization of Mexico. From Europe, tomato was introduced to North America in the eighteenth century. Tomato is grown worldwide for local use or as an export crop. In 2014, the global area cultivated for tomato was 5 million hectares with a production of 171 million tonnes and world's top five tomato producing countries in 2014 were China, India, the United States, Turkey and Egypt(FAOSTAT, 2017). Tomato plants show a wide climatic tolerance and are grown in both tropical and temperate regions around the world. Tomatoes are currently an important food component globally. Tomatoes are in fact the second largest vegetable both in terms of production and consumption (FAO, 2016). Tomatoes are rich source of vitamins and pro-vitamins (vitamin C, pro-vitamin A, β carotene, folate), minerals such as potassium and secondary metabolites such as lycopene, flavonoids, phytosterols and polyphenols (Beecher, 1998 and Luthria et al., 2006). Lycopene is an antioxidant that is good for the heart and effective against certain cancer. Tomato is a nutritious and delicious vegetable used in salad, soups and processes into stable products like ketchup, sauce, pickles paste, chutney and juice. In Bangladesh, tomato has great demand throughout the year but its production is mainly increased during the winter season. Tomato can be grown in a variety of geographical zones in open fields or greenhouses and the fruit can be harvested by manual or mechanical means. Under certain conditions (e.g. rejuvenation pruning, weeding, irrigation, frost protection), this crop plant can be perennial or semi-perennial, but commercially it is considered an annual (Geisenberg and Stewart, 1986).Thus the average yield of tomato in Bangladesh was 5.47 t ha^{-1} (BBS, 2015).

Tomatoes are the most popular home garden crop because of it's wide adaptability and easily growing process. Tomatoes can thrive in a wide range of climates and soil. But it's optimum temperature is around 26ºC (day) and 12ºC (night). Temperatures above 31ºC reduce the rates of flower fertilization, plant development and fruit ripening. The optimal temperature required at different stages of tomato development(Geisenberg and Stewart,1986). Tomatoes can grow in almost all types of soil except heavy clay. But loam and sandy loam soils are best for tomato production. Tomato is moderately tolerant to a wide range of pH. Tomato yield was higher in soils with a pH between 6.5 and 6.9 . Soils with acidic pH or salinity lead to a decrease in the size of the fruit (Doss, Evans and Turner, 1977; Papadopoulos and Rendig, 1983).

Plant species differ considerably in their need for water and nutrients and therefore, need different kinds of growing media to provide the best growing conditions. Due to this, different kinds of growing media are available on the market. Nutrients availability plays a vital role in good fruit production and thus preparation of proper growing media is the pre-requisite for better growth and production of tomato crops. So, the plant growing medium must be porous for root aeration and drainage and also capable of water and nutrient retention. A good growing medium is a place which provides sufficient anchorage or support to the plant, serves as reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the roots and atmosphere outside the root substrate (Argo, 1998 and Abad et al., 2002). These physical characteristics of a growing medium are determined by the components used. Growing media contain a variety of soilless ingredients such as peat moss, rice hulls, wood ash, vermiculite, perlite, shredded coconut husks (coir), composted bark or other composted materials. Field soils are generally unsatisfactory for the production of plants in containers because soils do not provide proper aeration, drainage and water holding capacity and they need to be pasteurized or fumigated to prevent the soil borne diseases and weeds.

The negative effects on the environment and human health caused by the current farming systems based on the application of chemical inputs such as pesticides and fertilizers have become a very common practice. Unfortunately, this cause water, soil and environment pollution which impacts human health and the whole food chain suffers . So, the environmental friendly microorganisms are used to stimulate plant growth and control pest and diseases and also serves as sources of food for plant. Nowadays, bacterial inoculations produce positive effects on plants without causing any type of harm. Currently, there are many studies that have analysed to increase crop production following the use of several bacterial strains. And, there is also a significant number of studies that not only try to increased the total yield, but also the nutritional benefits achieved by the application of beneficial microorganism on plants and the role of bacteria in improving the quality of crops (Ahemad and Kibret, 2014) .

The plant-associated microorganisms which cause beneficial effects on plants are considered as plant probiotic (Spence *et al*., 2012). Plant probiotics are microorganisms that confer benefits to the health of plants when used in specific amounts (Islam and Hossain, 2012) . In addition, they belong to the bacterial group Plant Growth Promoting Rhizobacteria (PGPR) which are able to colonize plant roots, promote plant growth through different direct and indirect mechanisms (Gunes, 2014), improve plant nutritional content and increase crop quality.

Bangladesh is a riverine country and now climate change is a critical issue of the world. So it increase the vulnerability of Bangladesh to floods and waterlogging condition. Therefore, the country needs to be equipped with adequate adaptation strategies, particularly those based on traditional knowledge and locally available materials. Hence, floating system holds enough potential to help the farming communities in the flood prone regions of Bangladesh to sustain lives and livelihoods during floods and long-term waterlogged conditions. Floating system is an age old indigenous farming practice in Bangladesh. Basically, Floating system is a unique hydroponics production system constructed with aquatic weeds, (especially water hyacinth-Eichhornia crassipe) or bamboo stick , which have been developed in the flood-prone areas of Bangladesh, especially suitable for the poor and small holder farmers. Floating system is an integrated system between aquatic animals like fish, snails or prawns and growing vegetables. Fish waste provides valuable nutrients to the plants, while the plants in return absorb the waste and clean the water for the fish. On the other hand, the beneficial bacteria exist on every moist surface and they convert the ammonia from the fish waste which is toxic to the fish and useless to the plants, first into nitrites and then into nitrates. The nitrates are relatively harmless to the fish and most importantly, they make terrific plant food. It is a key solution to reduce food insecurity and requirement of extra land for vegetable production. With the right choice of fish and plant species, floating system serves as a model of environmentally compatible and sustainable food production system(Chand *et al*., 2006).Considering the above facts, the present investigation was undertaken with the following **Objectives :**

- To determine the influence of growing media on the performance of tomato in the pond.
- To find out the effect of probiotics on the performance of tomato in the pond.
- To determine the interaction effect of growing media and probiotics on tomato production in the pond floating system.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERTURE

Tomato is one of the most popular and widely grown vegetable which received much attention to the researcher around the world. Growing media and probiotic has different effect on the performance of tomato. Various research has been done in different parts of the world to determine the different growing media effect on tomato performance. But very few research conducted over probiotic effect. Nevertheless, some of the important and informative works and research findings so far done at home or abroad on this aspect have been reviewed in this chapter.

2.1 Effect of Growing media

An experiment was carried out by Subramani *et al.* (2020) at Garacharm Research Farm, Central Island Agricultural Research Institute (ICAR), Port Blair during 2017-19 in a naturally ventilated polyhouse. They studied about the effect of soilless growing media on yield and quality of tomato under Tropical Island Condition. Eight treatments include cocopeat + vermiculite (1:1), cocopeat + perlite (1:1), cocopeat + sand (1:1), cocopeat + saw dust (1:1), cocopeat + vermiculite + saw dust (1:1:2), cocopeat + perlite + saw dust (1:1:2), cocopeat + sand +saw dust (1:1:2) and soil + farmyard manure (FYM) (3:1) were used. Results showed that among different growing media, cocopeat + saw dust (1:1) recorded maximum number of fruits/plant (12.33), fruit weight (51.2 g/fruit), and finally fruit yield (631 g/plant) and was at par with cocopeat + vermiculite + saw dust (1:1:2). Hence, it can be concluded that cocopeat + saw dust (1:1) as economically and environmentally sustainable media for soilless cultivation of tomato under island condition.

Jeevitha *et al*. (2019) studied about the effect of growing media on tomato seedling production. The treatments included different growing media such as, red soil, sand, cocopeat, vermicompost and farm yard manure in different ratios. Results revealed that, among the treatments, T9 (75% vermicompost + 25% cocopeat) recorded the highest germination percentage (93.54 %) and lowest days taken for germination (4.00 days). The seedling growth parameters like seedling height (19.80 cm), seedling girth (1.00cm), leaf area (9.00 cm^2), leaf chlorophyll content (28.77), shoot length (14.13 cm), root length (5.68 cm), seedling fresh weight (1.454 g), root to shoot ratio (0.373) and vigour index (1790.2) were significantly higher in the treatment T10 (75% Vermicompost + 25% FYM) than control.

Truong *et al*.(2018) studied to evaluate the effects of vermicompost(VC) application on growth, productivity and fruit quality of cherry tomato. Six treatments were designed including: VC with rice husk ash (RHS) and coconut fiber (CF). T1- 0% VC+ 50% RHS +50% CF (control), T2- 20%VC + 40% RHS + 40% CF, T3- 40% VC+ 30% RHS + 30% CF, T4- 60% VC + 20% RHS + 20% CF, T5- 80% VC + 10% RHS + 10% CF, and T6- 100% VC. The results showed that the pH, EC, N, P, K, Ca, and Mg available in media were increased with the addition of VC. This finding revealed that the addition of VC significantly improved the physic-chemical media properties, increasing the EC and also increasing the macronutrients in the media resulting in substantial increased the yield and quality of tomato fruits. It is concluded that, EC of VC was the key factor for the positive increase of the productivity and quality of tomato and the salinity (EC at 3.52 dS/m) causing restriction of water to fruits that resulted in the increase of the total soluble solids in tomato fruit and without affecting yield reduction.

Wang *et al*. (2017) was conducted an experiment to study the impacts of replacing mineral fertilizer with organic fertilizers for one full growing period on soil fertility, tomato yield and quality using soils with different tomato planting history. Four types of fertilization treatments were compared: (1) conventional fertilizer with urea, (2) chicken manure compost, (3) vermicompost, and (4) no fertilizer. The main results showed that: (1) vermicompost and chicken manure compost more effectively promoted plant growth, including stem diameter and plant height compared with other fertilizer treatments, in all three types of soil; (2) vermicompost improved fruit quality in each type of soil and increased the sugar/acid ratio and decreased nitrate concentration in fresh fruit compared with the CK treatment; (3) vermicompost led to greater improvements in fruit yield (74%), vitamin C (47%) and soluble sugar (71%) in soils; and (4) vermicompost led to greater improvements in soil quality than chicken manure compost, including higher pH (averaged 7.37 vs. averaged 7.23) and lower soil electrical conductivity (averaged 204.1 vs. averaged 234.6 µS/cm) at the end of experiment in each type of soil.

Haghighi *et al*. (2016) carried out an experiment to evaluate the ability of municipal solid waste compost (MSWC), peat, perlite and vermicompost (VC) to improve the growth of tomato (*Lycopersicon esculentum* L.) in hydroponic culture. Growth and physiological attributes were assessed. Results Among several ratios of MSWC, peat, perlite and VC, VC with 25 % compost increased the number of red fruits in the harvest period significantly more than the control. The use of VC, peat and perlite increased root fresh and dry weight, root volume, mean photosynthesis and the number of fruits at all physiological stages compared to the control. That means, Vermicompost can improve tomato growth physiology when used as one part of the substrate in hydroponic culture.

Atif *et al*.(2016) in Islamabad worked with different growing media effect on Tomato Seedlings. They used peat, compost (vegetable waste) and traditional practicing media (like soil, sand and farmyardmanure) alone and in combinations. Maximum germination percentage (95%), seedlings shoot length (26.67 cm), seedling height (35 cm), seedling vigor index (3325) and minimum days to emergence(15.33) were observed in T9 (peat, compost and traditional practicing media in 1:1:1 ratio). Maximum dry matter accumulation (34.80%) was recorded in T1(peat). Optimum growth of tomato seedlings was observed when peat, compost and traditional practicing media were used in equal proportions.

The study was conducted by Eswaran and Mariselvi (2016) to evaluate the effect of vermicompost and organic fertilizers on growth and yield of tomato plants. Various growth and yield parameters like mean Percentage of seed germination and seedling length, plant height, yield/plant, marketable yield/plant, mean leaf number, total plant biomass were recorded for each treatment. Almost all the growth, yield and quality parameters increased significantly as compared to control, though the increase within the treatments was not found to be significant. The present study suggested that vermicompost is more favorable for vigorous production of tomatoes. The vermicompost can be economically and environmentally favourable and also maintenance of soil environment.

An experiment was conducted by Jahan *et al*. (2014) at experimental field of the Soil Science Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh during the period from October 2008 to March 2009 to study the effect of vermicompost and conventional compost on the growth and yield of cauliflower. The experiment comprised of twelve treatments viz. T1: 100% Recommended Dose of Chemical Fertilizer (RDCF; RDCF= N250P35K65S40 Zn5B1 kgha^{-1}); T2: 80% RDCF; T3: 60% RDCF; T4: 100% RDCF +Vermicompost @ 1.5 tha-1; T5: 80% RDCF + Vermicompost @ 3 tha-1; T6: 60% RDCF +Vermicompost @ 6 tha-1; T7: Vermicompost @ 6 tha-1; T8: 100% RDCF +Conventional compost @ 1.5 tha-1; T9: 80% RDCF+ Conventional compost @ 3 tha-1; T10: 60% RDCF + Conventional compost @ 6 tha-1; T11: Conventional compost @ 6 tha-1 and T12: Control (No fertilization) following Randomized Complete Block Design with three replications. Maximum plant height (49.4 cm), number of leaves plant-1 (16.3), circumference of curd (46.5 cm), curd height (20.7 cm), total weight (1.60 kg plant-1), marketable weight (13.0 kg plant-1), curd yield (37.6 tha-1) and stover yield (29.7 tha-1) were found from T4 which was statistically identical with or followed by T8 and T5. From the experiment it was found that vermicompost was better that conventional compost in combination with chemical fertilizers.

Lari (2014) in order to evaluate the effect of cocopeat and vermicompost biofertilizers at different ratio's as media on qualitative traits of pepper. It was a randomized complete block design with three replication in the greenhouse. Experimental treatments were: 1-vermicompost:perlite(1:1), 2-cocopeat:vermicompost (1:1), 3-cocopeat: perlite: vermicompost (2:1:1), 4-cocopeat: perlite:vermicompost (1:2:1), 5-cocopeat: perlite: vermicompost(1:1:2), 6-cocopeat: perlite(1:1) and the three varieties of Capsicum were as follows: Capsicum annum var. Alonso, Roxy, Baiela. The result demonstrated that there are a significant difference in amount of Chlorophyll a in 1% and Chlorophyll b and Carotenoids was significant at the 5% level of significance. The results of vermicompost : perlite : cocopeat (2:1:1) in characters Chlorophyll a and b has the highest average. Finally The vermicompost: perlite : cocopeat (1:1:2) was have highest average of carotenoids, Chlorophyll a and b.

Alam (2011) conducted an experiment at the Bangladesh Agricultural Research Institute (BARI)central farm to evaluate the efficiency of conventional compost (CC) and vermicompost (VC) on the yield of tomato. There were ten treatments replicated three times. It was observed that 75% RDCF (Recommended Dose of Chemical Fertilizer)+VC at 2.0 t/ha gave the tallest plant and maximum number of fruit per plant and thereby produced the highest yield (61.1 t/ha) of tomato. The yield was statistically identical with 100% RDCF (58.1 t/ha); and 75% RDCF+CC at 2.0 t/ha (56.6 t/ha). The lowest yield (19.0 t/ha) was observed in native fertility (no fertilizer) which was followed by 0% RDCF+CC at 10 t/ha (38.9 t/ha). Vermicompost exhibited better performance than conventional compost in all studied parameters except individual fruit weight.

Kumar and Sharma (2014) studied by comparing different treatment combinations give useful indication on the possibility of increasing yield, quality and component traits and decreasing occurrence of soil born diseases by using soil less growing media (Vermicompost: sand; 2:1) along with seedling treatment of Azotobacter and fertigation dose of 300 kg NPK per ha.

Ramirez *et al.* (2014) conducted a field experiment to evaluate different vermicompost doses in tomato crops (*Solanum lycopersicum* L.) in northern Sinaloa, Mexico. Vermicompost doses of 0, 500, 1000, 1600, 2000 and 4000kg ha^{-1} were tested including a control, in a completely randomized design with three replicates per treatment. The estimated variables were fruit size, number and weight. The addition of more than 4000 kg/ha of vermicompost significantly increased the fruit number and size in tomato plants hence it is considered a viable option for use in commercial tomato crops.

Basheer and Agrawal (2013) aimed to understand the effect of Vermicompost on the growth and productivity of tomato plant. The Vermicompost produced from the mixture of garden waste and cow dung using Eudrilus eugeniae was used in growing tomato plants under field conditions. The treatment affected the seed germination of the test crop significantly. Plant height, number of leaves and fruit weight were higher in the Vermicompost treated field as compared to control and no disease incidence was observed in the fruits of Vermicompost treated plot. The study revealed that amendment of soil with Vermicompost affected tomato crop differently.

Chanda *et al*. (2011) studied on the effect of vermicompost and other fertilizers on cultivation of tomato plants. Six types of experimental plots were prepared where T1 was kept as control and five others were treated by different category of fertilizers (T2-Chemical fertilizers, T3-Farm Yard Manure(FYM), T4-Vermicompost, T5-FYM supplemented with chemical fertilizers and and T6 vermicompost supplemented with chemical fertilizer respectively).The treatment plots (T6) showed 73% better yield of fruits than control. Besides, vermicompost supplemented with N.P.K treated plots (T5) showed better results with regard to fresh weight of leaves, dry weight of leaves, dry weight of fruits, number of branches and number of fruits per plant from other fertilizers treated plants.

Joshi *et al*. (2010) experimented with the Cattle dung vermicompost (VC) of different proportions mixtures namely Soil (control), VC15 (Soil+15% VC), VC30 (Soil+30% VC), VC45 (Soil+45% VC). Germination percentage was found the maximum at VC15 treatment than decreased in the subsequent treatments. Almost all the growth, yield and quality parameters increased significantly as compared to control, though the increase within the treatments was not found to be significant.

Azarmi *et al*.(2008) investigated the effects of vermicompost on growth, yield and fruit quality of tomato (*Lycopersicum esculentum* var. Super Beta) in a field condition. The experiment was a randomized complete block design with four replications. The different rates of vermicompost (0, 5, 10 and 15 t ha^{-1}) was incorporated into the top 15 cm of soil. The results showed that addition of vermicompost at rate of 15 t ha^{-1} significantly (at $p<0.05$) increased growth and yield compared to control.

Ahirwar and Hussain (2004) studied to evaluate the transplant quality and field performance of vegetable grown in vermicompost. Tomato (*Lycopersicon esculentum* Mill.), Eggplant (*Solanum melongena* L.), Pepper (*Capsicum annuum* L.), Potato, Sweet corn hybrids, Pak choi, Spinach and Turnip vegetable was used. Growth of vegetable transplants was positively affected by addition of vermicompost, perhaps by altering the nutritional balance of the medium. Transplant quality was improved in peppers and eggplants, while tomato transplant quality was slightly reduced. There were no significant differences in field performance.

A field experiment was conducted by Reddy and Rao (2004) to study the Growth and yield of bitter gourd (*Momordica charantia* L.) as influenced by vermicompost and nitrogen management practices in Hyderabad, Andhra Pradesh, India, 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.

Arancon *et al*. (2003) applied vermicompost in small replicated field plots planted with tomatoes (*Lycopersicon esculentum*) and bell peppers (*Capsicum anuum grossum*) at rates of 10 t ha^{-1} or 20 t ha^{-1} in 1999 and at rates of 5 t ha^{-1}or 10t ha^{-1} in 2000. Food waste and recycled paper vermicomposts were applied at the rates of 5 t ha^{-1} or 10 t ha^{-1} in 2000 to replicated plots planted with strawberries (*Fragaria spp*.). Inorganic control plots were treated with recommended rates of fertilizers only and all of the vermicompost treated plots were supplemented with amounts of inorganic fertilizers to equalize the initial N levels available to plants in all plots during transplanting. The marketable tomato yields in all vermicompost treated plots were greater than yields from the inorganic fertilizer treated plots. There were significant increases in shoot weights, leaf areas and total marketable fruit yields of pepper plants from plots treated with vermicomposts compared to those from plots treated with inorganic fertilizer only. Leaf areas, numbers of strawberry suckers, numbers of flowers, shoot weights and total marketable strawberry yields increased significantly in plots treated with vermicompost compared to those that received inorganic fertilizers only.

Chaudhary *et al*. (2003) conducted a field experiment in Orissa, India starting from 1999 to investigate the use of vermicompost in cabbage cv. S-22 and tomato cv. Golden Acre production. Vermicompost was prepared using Gliricidia leaves and *Eisenia fetida* and was applied at 100 and 200 g/plant with or without farmyard manure (FYM), at 250 and 500 g/plant. The treatment received VC at 200 g/plant + FYM at 250 g/plant was the best for obtaining sustainable yields in both crops.

2.2 Effect of probiotic

EL-Aidy *et al.* (2020) conducted an experiment during two successive summer seasons under greenhouse conditions. The effect of different amendments including plant probiotics, silicon, sucrose and paclobutrazol were investigated on growth and quality of tomato seedlings under heat stress in a greenhouse. Their findings showed that tomato seedlings could overcome the high temperature stress under greenhouse conditions, with foliar application of plant probiotics, sucrose and silicon.

Gou *et al*. (2020) studied an experiment to determine the effect of Biofertilizers with beneficial rhizobacteria in chilli. In this study, *Bacillus sp*. WM13-24 and *Pseudomonas sp*. M30-35 isolated from the rhizosphere of *H. ammodendron* and *Bacillus amyloliquefaciens* GB03 and *Sinorhizobium meliloti* ACCC17578 as well-studied beneficial strains were used to prepare two types of biofertilizer, WM13-24 biofertilizer containing Bacillus sp. WM13-24 and integrated biofertilizer containing all the four strains. Results presented here showed that WM13-24 biofertilizer and the integrated biofertilizer improved chili plant growth, fruit yield and quality and the rhizosphere soil nitrogen content, enzyme activities and the quantity and biodiversity of viable bacteria. Compared to the control, WM13-24 biofertilizer and a commercial biofertilizer, the integrated biofertilizer performed best in significantly increasing plant height, stem diameter, leaf length and width, chlorophyll content, fruit yield, soluble sugar content, ascorbic acid content, organic acid content. This study provided a theoretical and practical basis for large scale development of integrated biofertilizers using beneficial rhizobacterial strains from the desert plant rhizosphere.

Roshni *et al*.(2019) carried out an experiment at the Horticultural Research Station, Dr.Y.S.R. Horticultural University, Andhra Pradesh during Rabi 2017-18 to study the effect of bio-inoculants and inorganics on quality characters of carrot. Two factors were taken, the first factor being the chemical fertilizers at three levels (100%, 75%, 50% of RDF) and the second factor was the different combinations of five biofertilizers (PSB, KSB, Azospirillum, Azotobacter, VAM).The experimental design adopted was the factorial RBD with 12 treatment combinations. The results revealed that the individual effect of chemical fertilizers at level 100% RDF (75:60:50 kg/ha) and biofertilizer's level PSB+ KSB+ Azospirillum+ Azotobacter + VAM showed a significant difference in quality characters compared to the other levels. The characters viz., total soluble solids (9.50°Brix), β-carotene content (5.29 mg/100 g), total sugars (10.94 %), reducing sugars (6.23 %), non-reducing sugars (4.71 %) and total protein content (866.63 mg/100g) of carrot were recorded the highest with the application of 100% RDF+PSB+ KSB+ Azospirillum+ Azotobacter+ VAM. The lowest core diameter (2.11 cm), a favourable character was achieved with the application 50% RDF+ PSB+ KSB+Azotobacter. The use of biofertilizers in combination with the chemical fertilizers would yield higher quality produce and also aid in adding steps towards sustainable crop production by conserving the soil health.

Rahman *et al*.(2018) studied to evaluated the effects of two plant probiotic bacteria, *Bacillus amylolequefaciens* BChi1 and *Paraburkholderia fungorum* BRRh-4 on growth, fruit yield and antioxidant contents in strawberry fruits. Root dipping of seedlings (plug plants) followed by spray applications of both probiotic bacteria in the field on foliage signifcantly increased fruit yield (up to 48%) over non-treated control. Enhanced fruit yield likely to be linked with higher root and shoot growth, individual and total fruit weight/plant and production of phytohormone by the probiotic bacteria applied on plants. Interestingly, the fruits from plants inoculated with the isolates BChi1 and BRRh-4 had signifcantly higher contents of phenolics, carotenoids, favonoids and anthocyanins over non-treated control. Total antioxidant activities were also signifcantly higher ($p<0.05$) in fruits of strawberry plants treated with both probiotic bacteria. To the best of our knowledge, this is the first report of signifcant improvement of both yield and quality of strawberry fruits by the application of plant probiotic bacteria BChi1 and BRRh4 in a field condition.

Jimenez-Gomez *et al*.(2017) studied how bacterial inoculations produce positive effects on yields. In addition to the notable enhancement of crop production, many studies have shown how the application of bacteria has positive effects on food quality such as improved vitamin, flavonoid and antioxidant content, among other benefits. This advantage is interesting with respect to food that is consumed raw, such as fruits and many vegetables, as these bioactive molecules are maintained up until the moment the food is consumed. As regards this review focuses on the collection of studies that demonstrate that microorganisms can act as plant probiotics of fruit and horticultural crops, essential types of food that form part of a healthy diet.

Acharjee (2017) experimented in order to provide an experimental evidence on the positive impact of bio-fertilizer instead of chemical fertilizer on agricultural field. Present study attempted to collect 50 samples of *Brassica oleracea* (25 were treated with bio-fertilizer and 25 were chemically treated) from different agricultural land of rural area in Bangladesh. The samples were processed to examine the microbiological and clinical aspects of both bio-fertilizer and chemical fertilizer on vegetables through several common, traditional and replicable cultural and biochemical tests. Both samples were found to be contaminated with total viable bacteria and fungi up to the range 108 & 106 cfu/g, respectively. The elevated range of pathogenic contamination (*Staphylococcus spp.*, *Bacillus spp.*, *Pseudomonas spp*.) was found in both samples within the range of 102 to 106 cfu/g. In case of biofertilizer treated vegetable the contamination of *Staphylococcus spp*. was prominent up to 106 cfu/g and the same existence was found for chemically treated vegetable. *Bacillus spp*. and *Pseudomonas spp*. were found 104 & 105 cfu/g, respectively in biofertilizer treated vegetable while the contamination was noticed up to 102 & 104 cfu/g in chemically treated vegetable respectively. Another important era of this study is drug resistant pattern, most of the isolates exhibited resistance against commonly used antibiotics while several isolates were noted to be multi-drug resistant (MDR). The drug resistance strains were remarkably high in chemically treated vegetable whereas maximum antibiotics were extremely effective against the bacteria isolated from biofertlizer treated vegetable.

Muhammad *et al*.(2017) conducted an field experiment on effect of biofertilizer and plant spacing on growth, yield and fruit quality of brinjal. Four Biofertilizer levels (B1:0, B2: 6.5, B3: 8.5 and B4: 10.5L ha^{-1}) and four Plant spacing (S1: 60×30, S2: 60×60, S3: 60×90 and S4: 60×120cm) were used. A Randomize Complete Block Design (RCBD) with split-plot arrangement was used in such a way that biofertilizer levels were subjected to main plots and plant spacing was allotted to sub plots. Biofertilizers and plant spacing significantly ($P \leq 0.05$) affected most of the attributes studied. Among the Biofertilizer treatments, maximum plant height (108.72cm), number of leaves $plant^{-1}$(135.33), leaf area (90.73cm^2), fruit weight (99.36gm), yield $plant^{-1}$ (1.77kg), total yield (37.21tons ha^{-1}), fruit pH (5.59), vitamin C (3.00mg) and fruit firmness (2.06kg cm^{-2}) were recorded in biofertilizer application @6.5L per hectare. In case of different plant spacing maximum plant height (102.35cm), number of leaves $plant^{-1}$ (123.45), leaf area (86.41cm^2), fruit weight $plant^{-1}$ (89.54gm), yield $plant^{-1}$ (1.63kg), total yield (40.64tons ha^{-1}), fruit pH (5.44), vitamin C (2.70mg) and fruit firmness (2.05kg cm^{-2}) were recorded in 60x60 cm. It is concluded that biofertilizer application @6.5 L ha^{-1} with plant spacing 60x60 cm increased the qualitative and quantitative attributes of brinjal.

Fei *et al*. (2016) conducted an experiment to find out the effects of two strains of probiotic bacteria (*Bacillus megaterium* BM and *Bacillus amyloliquefaciens* BA) combined with chemical fertilizers and vermicompost on the soil property, the yield and quality of tomato. The result showed that vermicompost combined with probiotics not only increased the tomato yield, soluble sugar, vitamin C and protein contents, sugar/ acid ratio of fruit, and reduced the organic acid and nitrate nitrogen contents of fruit but also increased the soil pH and nitrate nitrogen content, and reduced soil electric conductivity when compared with chemical fertilzers. This improved efficiency was better than that by chemical fertilizers combined with probiotics. So their results suggested that probiotics and vermicompost could be used as alternatives of chemical fertilizers in tomato production and soil fertility improvement.

Saeed *et al*. (2015) experimented to evaluate the effect of chemical fertilizers and bio-fertilizers was done on growth and biochemical parameters in cucumber plant. An experiment was conducted in Randomized Completely Blocks Design (RCBD) with four replication. The treatment were (T1 = Control, T2 = Bio-fertilizer, T3 = Chemical and T4 = Combination treatment (biofertilizer and 1/2 chemical)) at Agricultural Technical Institute of Bakrajo, Sulaymania, Iraq during 2014. The bio-fertilizer used in this study was Azoto barwar1 and chemical fertilizer was urea. The material consisted of one cultivar of cucumber sayfe species. The results indicated that there were significant difference between the application of bio-fertilizer and chemical fertilizer for yield and yield component traits. This study indicated that a combination treatment of bio-fertilizer and chemical fertilizer had significant effect and increased the yield and growth traits of cucumber. According to this study using bio-fertilizers has increased yield and yield component of cucumber significantly.

Limanska *et al.* (2013) studied about the *Lactobacillus plantarum* effect on germination and growth of tomato seedlings. Significant stimulation of germination of tomatoes (*Lycopersicon esculentum* Mill. cv Odessa plum) with poor initial germination capacity was achieved by soaking their seeds during 6 hour in suspensions of nine out of ten *Lactobacillus plantarum* strains tested. The increase in percentage of germination ranged from 15.1 to 7.6 %. Lengths of shoots, main and lateral roots and development of root hairs increased after inoculation of seeds with studied L. plantarum strains. The treatments of seeds with L. plantarum expanded shoot lengths by 16.4–18.2 % .

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted to know the performance of tomato in response to growing media and probiotics in the pond floating system. The details of the materials and methods of this research work were described in this chapter as well as on experimental materials such as site, climate, experimental design, layout, materials used for experiment, treatments, seed sowing and transplanting of seedling, raft preparation, intercultural operations, harvesting, collection of data and statistical analysis which are given below:

3.1 Experimental site

The experiment was carried out on the pond of Agri-business faculty building of Sher-e-Bangla Agricultural University, Dhaka. The location of the site in 23°74" N latitude and 90°35" E longitude with an elevation of 8.2 meter from sea level, which have been shown in Appendix I.

3.2 Experimental period

The experiment was conducted during the Rabi season from October 2019 to January 2020. Seeds was sown on 22 October 2019, seedling transplanting was done on 20 November, 2019 and harvested upto January, 2020.

3.3 Climatic condition

The experimental site is located in subtropical region where climate is characterized by heavy rainfall during the months from April to September (Kharif season) and scanty rainfall during rest of the month (Rabi season). The maximum and minimum temperature, humidity, rainfall of cropping season October 2019 to march 2020 has been presented in Appendix II.

3.4 Planting materials

The tomato cultivar i.e. BARI Tomato 14 seed was used in this experiment. Seed was collected from Bangladesh Agricultural Research Institute (BARI).

3.5 Experimental design

The experiment was laid out in Completely Randomized Design (CRD) having two factors with three replications. This experiment consists of 27 plastic pot. Plastic pots were used to holding three different media and each having three replications. The plastic pot size was 14 inch in size. Three types of media were used in this experiment.

3.6 Treatments

The experiment consisted two factors and that was

Factor A: Growing Media

a) G_1= 10% khoa + 90% coco peat (control)

b) G_2= 10% khoa + 60% coco peat + 30% vermicompost

c) G_3= 10% khoa + 45% coco peat + 45% vermicompost

Factor B: Different level of probiotics

a) P_0= 0 gm/pot (control)

b) P_1= 5 gm/pot

c) P_2= 10 gm/pot

Treatment combinations: G_1P_0, G_1P_1, G_1P_2, G_2P_0, G_2P_1, G_2P_2, G_3P_0, G_3P_1, G_3P_2.

3.7 Raft Preparation

The raft is made by using Cocksheet, Bamboo stick and Thread. Three cocksheets are used to set 27 plastic pots in the pond. The length and width of each cocksheet is 7ft and 3ft and thickness of the cocksheet is 3 inch. Nine pots are placed in each sheet.

3.8 Bed Preparation and sowing of seeds

Tomato seedlings were raised in the seedbed situated on a relatively high land at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the seedbed was 3 m x l m. The soil was well prepared with the help of spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and 5 kg well rotten cowdung was applied during seedbed preparation. The seeds were sown on 22 October, 2019 and after sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg/ha around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place within 5 to 6 days after sowing. Necessary shading by using polythene was provided over the seed bed to protect the young seedlings from scorching sun or heavy rain. Weeding, mulching and irrigation were done from time to time as when required.

3.9 Pot preparation for seedling transplanting

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

3.10 Application of probiotics

The selected probiotic was applied during the final pot preparation. Before application, probiotic was mixed with 500ml of water and 100gm of brown sugar and than applied in the pot. Similarly, 100gm of brown sugar with 500ml of water were also applied in the controlled pot. These probiotic contains *Bacillus pumilus* and *Bacillus safensis* bacteria.

3.11 Transplanting of tomato seedling

After putting the media in the plastic pot, tomato seedling were collected from the Horticulture Farm of Sher-e-Bangla Agricultural University and planted on the pot. 30 days old seedlings were used for translanting. 27 seedlings were used for transplanting. Translanting was done on 20 November, 2019.

- Mustard oil cake was used in each pot in equal proportion at 15 days interval

3.12 Pond water quality parameters studied

Parameters	**Value**
Temperature	19°C
pH	7.5
Dissolved oxygen (DO)	6.41 mg L^{-1}
Ammonia (NH_3)	0.04 mg L^{-1}
Phosphate (PO_4)	0.75 mg L^{-1}
Nitrate (NO_3)	0.08 mg L^{-1}

3.13 Methods of measuring water quality parameters

3.13.1 Determination of water temperature, p^H ,dissolved oxygen (DO) and NH_3

Temperature of pond water was determined by using digital thermometer and P^H of water was measured by using p^H meter (Hanna-HI 98127). Dissolved oxygen is one of the most important parameter to determine the overall health of water. It was measured by using DO meter (Hanna DO meter, model 9142). NH_3 levels in pond water was measured by using ammonia test kit (Hanna HI 91700-01).

3.13.2 Determination of PO_4

A small amount of the sample was acidified with concentrated nitric acid, in which a little ammonium molybdate was added. The presence of phosphate ions was indicated by the formation of a bright yellow precipitate layer of ammonium phosphomolybdate. The appearance of the precipitate can be facilitated by gentle heating.

3.13.3 Determination of NO_3

NO_3 was measured by collecting a sample from the pond water into a clean glass jar. Then placed a NO_3 strip in the water sample for 10 seconds. After 10 seconds, removed the strip from the water sample. Let the color develop for 30 seconds, and then compared the indicator pad with the color chart to measure nitrates in mg/L.

3.14 Intercultural operations

Intercultural operations was done whenever needed for better growth and development. Intercultural operations followed in the experiment were weeding and staking etc.

3.15 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.

3.16 Parameters of data collection

The experiment was conducted to know the performance of tomato in the pond floating aqua-vegeculture system. The data of following parameters were collected-

3.16.1 Growth parameters

1. Plant height (cm)
2. Number of leaves per plant
3. Number of branches per plant
4. Number of flower clusters per plant
5. Chlorophyll content

3.16.2 Yield contributing parameters

1. Number of flowers per plant
2. Number of fruits per plant
3. Fruit P^H
4. Ascorbic acid
5. Brix percentage
6. Fruit length (cm)
7. Fruit diameter (cm)
8. Single fruit weight (gm)
9. Yield per plant (kg)

3.17 Procedure of data collection

3.17.1 Plant height (cm)

Plant height was taken at three times and measured in centimeter from ground level to tip of the main stem from each plant of each treatment and mean value was calculated.

3.17.2 Number of leaves per plant

Total number of leaves was counted at three times from each plant of the treatment and mean value was calculated.

3.17.3 Number of branches per plant

Total number of branches was counted at three times from each plant of the treatment and mean value was calculated.

3.17.4 Chlorophyll content

A segment of 20 mg from middle portion of leaf was used for chlorophyll analysis. Chlorophyll content was measured using SPAD meter.

3.17.5 Number of flower cluster per plant

Number of flower cluster per plant was counted from first cluster appearance. Number of cluster was recorded for each treatment.

3.17.6 Number of flowers per plant

Number of flower per plant was counted from each of the treatment. The total number of flower per plant was counted and average number of flower was recorded.

3.17.7 Number of fruits per plant

Number of fruit was counted from first harvest stage to last harvest. The total number of fruits per plant was counted and average number of fruit was recorded.

3.17.8 Measuring of fruit p^H

P^H was measured by using p^H meter. For preparing sample solution of fruits, tomatoes are chopped into small pieces and ground into a fine paste by mortar and pestle. The tomato juice was transferred into a test tube and the pH of the paste was determined by inserting the electrodes into the paste and stabilized readings were recorded.

3.17.9 Determination of ascorbic acid content

Ascorbic acid content was estimated by using 2,6-Dichlorophenol indophenol (DCPIP) visual titration method (Rangana, 2004). 5gm tomato fruit sample was blended, juice was filtered by sieve. Volume was made up to 100 ml by adding oxalic acid.10 ml from solution was taken in conical flask and titrated against DCPIP (Standard dye) to a pink end point which should persist for at least 15 seconds. Ascorbic acid content in terms of mg/100 g pulp weight was calculated using the following formula:

Ascorbic acid (mg/100g):

$$=\frac{\text{Titra} \times \text{dye factor} \times \text{Volume made up}}{\text{Aliquot of extract taken for estimation} \times \text{wt.or vol.of sample taken for estimation}} \times 100$$

3.17.9.1 Oxalic acid solution preparation

It was prepared by dissolving 50g oxalic acid powder in 1000ml distilled water.

3.17.9.2 Dye solution preparation

It was prepared by dissolving 260 mg of the sodium salt of 2,6-dichlorophenol indophenol in approximately 1000 ml of hot distilled water containing 210 mg of sodium bicarbonate.

3.17.9.3 Standardization of dye solution

Ten milliliters (10 ml) of standard ascorbic acid solution was taken in a conical flask and 5 ml of oxalic acid was added to it. A micro burette was filed with the dye solution. The content of the conical flask was titrated with dye solution. The content of conical flask was titrated with dye till the pink colored end point appeared. The milliliters of dye solution required to complete the titration was recorded. Dye factor was calculated using the following formula: Dye factor = 0.5/ titrate value

3.17.10 Measuring of fruit brix percentage

Brix content of tomato pulp was estimated by using brix refractometer. Two drop of tomato juice squeezed from the fruit pulp on the prism of the refractometer. Brix percentage was obtained from the direct reading of the instrument.

3.17.11 Length and diameter of fruit (cm)

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 length and diameter of the same 10 randomly selected fruits as harvested was measured and the average was calculated in cm.

3.17.12 Individual fruit weight (gm)

To estimate individual fruit weight, six fruits in every plant and every harvest were considered. Thus, the average individual fruit weight was measured.

3.17.13 yield per plant (kg)

To estimate yield, all the fruits of each plant was considered. Thus the average yield per plant was measured.

3.18 Statistical analysis

The recorded data on different parameters were statistically analyzed using STATISTIX 10 software and mean separation was done by LSD test at 5% level of significance.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

This experiment was conducted to know the effect of growing media and probiotics on the performance of tomato in the pond floating system. Data on different parameters were analyzed and discussed. The results have been presented in tables and figures and possible interpretations have been showed under the following headings.

4.1 Plant height

Plant height was recorded at 30, 45 and 60 days after transplanting. Plant height showed significant variations for the different growing media (Figure 1 and Appendix II). Data revealed that growing media G_3 produced the tallest plant (46.83 cm, 74.53 cm and 95.24 cm at 30, 45 and 60 DAT, respectively) over G_1 (37.68 cm, 60 cm and 75.06 cm at 30, 45 and 60 DAT, respectively). Under the present study, control treatment also performed well, might be due to the presence of nutrients in the pond water which was uptake by the root system of tomato. A similar result was observed by Jeevita *et al*. (2019), Basheer and Agrawal (2013) which supported the present study.

Marked variation was observed in the plant height of tomato due to the application of different levels of probiotic (Figure 2 and Appendix II). The tallest plant height was found in P_2 treatment (43.13 cm, 70.44 cm and 89.69 cm at 30, 45 and 60 DAT) and the shortest plant was observed in P_0 treatment (40.70 cm, 66.94 cm and 82.37 cm at 30, 45 and 60 DAT, respectively). This fact that, P_2 treatment (10 gm) probiotic bacteria are properly multiplied and that provide proper condition to the tomato plant for their growth under pond floating system. Almost same result was found by Muhammad *et al*.(2017

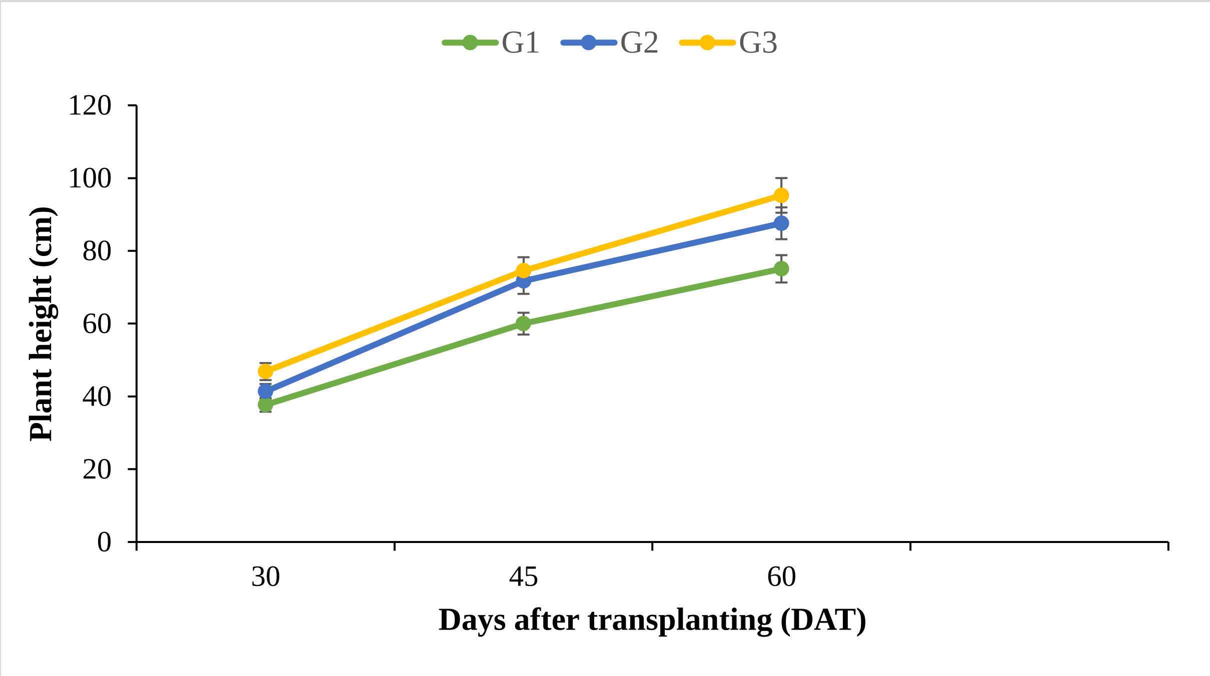

Figure 1. Effect of growing media on plant height of tomato

Here, DAT= Days after transplanting; G_1= 10% khoa + 90% coco peat(control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost. (Vertical bar represents standard error)

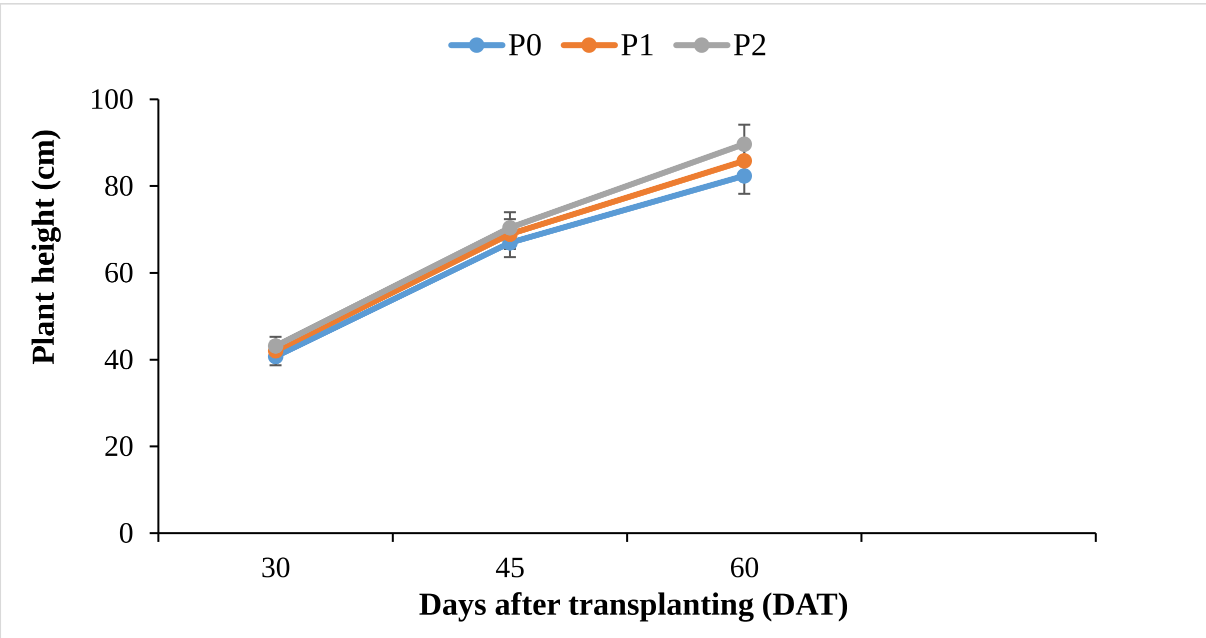

Figure 2. Effect of probiotics on plant height of tomato

Here, DAT= Days after transplanting; P_0= 0 gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot. (Vertical bar represents standard error)

There was a significant variation was observed in plant height of tomato due to the interaction of growing media and probiotic level at 30, 45 and 60 days after transplanting (Table 1 and Appendix II). It was observed that, The tallest plant was recorded from the combined effect of G_3P_2 (10% khoa + 45% cocopeat + 45% vermicompost and 10gm probiotic) and plant height ranges from 47.73cm to 99.76cm. While the shortest plant was recorded from the treatment combination of G_1P_0 (Control) and plant height was ranges from 36.53cm to 72.05cm. It was indicated that the combination of growing media and probiotic assure the suitable condition for the growth and development of tomato and the ultimate result is the tallest plant at different growth stages.

Table 1. Combined effect of growing media and probiotics on plant height of tomato

Treatments	**Plant height (cm) at**		
	30 DAT	**45 DAT**	**60 DAT**
G_1P_0	36.53 e	58.71 e	72.05 h
G_1P_1	37.46 de	60.02 de	75.02 g
G_1P_2	39.06 cd	61.26 d	78.11 f
G_2P_0	40.03 c	71.11 c	84.23 e
G_2P_1	41.45 bc	71.83 c	87.31 d
G_2P_2	42.60 b	72.37 c	91.21 c
G_3P_0	45.55 a	71.03 c	90.85 c
G_3P_1	47.22 a	74.87 b	95.11 b
G_3P_2	47.73 a	77.71 a	99.76 a
LSD (0.05)	2.43	1.77	1.1
CV (%)	3.37	1.49	0.68

Here, DAT= Days after transplanting; G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost; P_0= 0 gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot.

4.2 Number of leaves per plant

Number of leaves per plant of tomato increased gradually with the advancement of growth stage up to the harvest (Figure 3 and Appendix III). The maximum number of leaves was obtained from the G_3 treatment (23.77, 35.22 and 42) compared to G_1 treatment (17.11, 25.33 and 33.22) at 30, 45 and 60 DAT, respectively. The fact that, growing media G_3 provide proper nutrient and support to the plant for their proper growth and development. The research of Basheer and Agrawal (2013) support the present study.

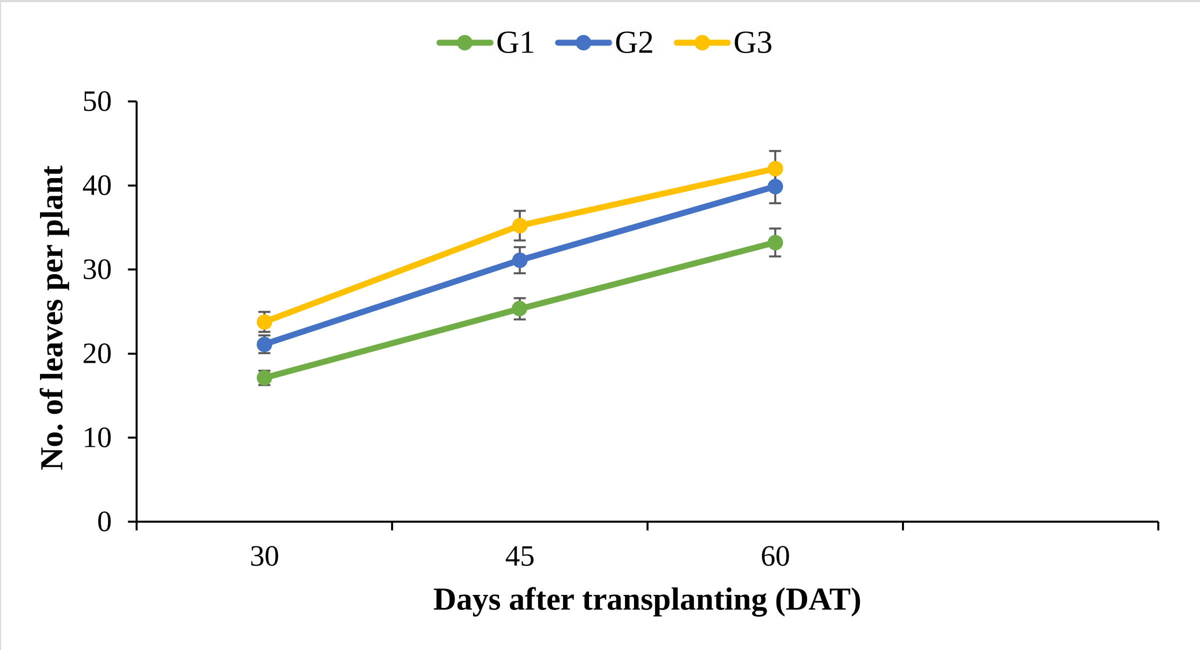

Figure 3. Effect of growing media on number of leaves per plant of tomato

Here, DAT= Days after transplanting; G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost. (Vertical bar represents standard error)

Number of leaves per plant of tomato varied significantly due to the aplication of different level of probiotic (Figure 4 and Appendix III). The data revealed that P_2 produced maximum number of leaves (23.88, 33.55 and 41) followed by P_1 and P_0 produced minimum number of leaves (17.33, 27.44 and 35.77) at 30, 45 and 60 days after transplanting. This might be due to the proper multiplication of P_2 probiotic bacteria, which helps the plant in their growth and development. A similar result also observed by Muhammad *et al*.(2017).

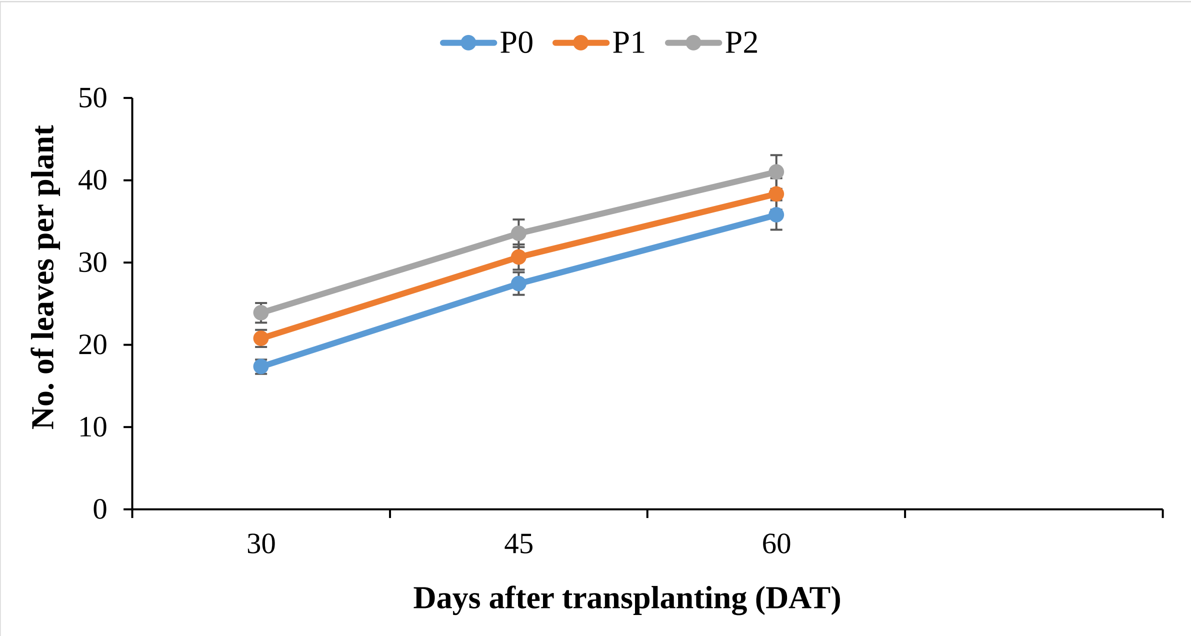

Figure 4. Effect of probiotics on number of leaves per plant of tomato

Here, DAT= Days after transplanting; P_0= 0 gm probiotic(control); P_1= 5 gm probiotic; P_2= 10 gm probiotic/pot. (Vertical bar represents standard error)

Combined effect of growing media and probiotics showed statistically significant variation on number of leaves per plant of tomato (Table 2 and Appendix III). It was observed that, the interaction of G_3P_2 produced the maximum number of leaves (27, 39.66, 44.66), while G_1P_0 produced the minimum number of leaves (14.33, 23.33, 31.33) per plant of tomato at 30, 45 and 60 days after transplanting. From the result, it can be concluded that the treatment G_3P_2 provided better growing condition and supply adequate nutrients to the plants, resulting in the highest number of leaves per plant of tomato.

Table 2. Combined effect of growing media and probiotics on number of leaves per plant of tomato

Treatments	Number of leaves per plant at		
	30DAT	**45DAT**	**60DAT**
G_1P_0	14.33 d	23.33 e	31.33 d
G_1P_1	17.66 cd	25.33 de	33.00 cd
G_1P_2	19.33 c	27.33 cde	35.33 bcd
G_2P_0	17.66 cd	28.33 cde	36.00 bcd
G_2P_1	20.33 bc	31.33 bcd	40.66 abc
G_2P_2	25.33 a	33.66 abc	43.00 ab
G_3P_0	20.00 bc	30.66 bcd	40.00 abc
G_3P_1	24.33 ab	35.33 ab	41.33 ab
G_3P_2	27.00 a	39.66 a	44.66 a
LSD (0.05)	4.89	6.39	7.79
CV (%)	13.81	12.20	11.84

Here, DAT= Days after transplanting; G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost; P_0= 0 gm(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot .

4.3 Chlorophyll content

The recorded data of chlorophyll content showed a wide range of variations (Table 3 and Appendix V), whereas the highest chlorophyll content (70.92) was recorded from the media G_3 which was statistically similar to G_2 and the lowest chlorophyll value (45.23) was recorded from media G_1. The findings is similar to Jeevita *et al*. (2019), Lari(2014).

Table 3. Effect of growing media and probiotics on chlorophyll SPAD value, number of branches, flower cluster, flowers and fruits per plant of tomato

Treatments	Chlorophyll SPAD value	Number of branches per plant	Number of flower cluster per plant	Number of flowers per plant	Number of fruits per plant
G_1	45.23 b	3.22 c	12.34 b	29.23 c	16.89 c
G_2	62.04 a	5.33 b	21 a	46.89 b	27.45 b
G_3	70.92 a	6.44 a	21.89 a	55.67 a	29.67 a
LSD(0.05)	12.31	0.74	2.42	2.07	1.45
CV(%)	20.94	14.91	13.31	4.78	5.94
P_0	53.48 b	4.22 c	16.45 b	37.67 c	21.34 c
P_1	60.64 a	5 b	18.67 ab	44.89 b	25.23 b
P_2	64.05 a	5.78 a	20.12 a	49.23 a	27.45 a
LSD(0.05)	12.31	0.74	2.42	2.07	1.45
CV(%)	20.94	14.91	13.31	4.78	5.94

Here, G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost; P_0= 0 gm(control); P_1= 5 gm probiotic; P_2= 10 gm probiotic/pot.

The SPAD value of tomato plant showed statistically significant variations (Table 3 and Appendix V) among treatments. Maximum amount of chlorophyll (64.05) contain by P_2, while minimum amount of chlorophyll (53.48) contain by P_0 treatment in aquavegeculture system. A similar result was also observed by Gou *et al.* (2020) which supported the present study.

The interaction effect of growing media and probiotics had significant variations in chlorophyll content of tomato plant (Table 4 and Appendix V). From the data, it was observed that treatment combination G_3P_2 contain maximum amount (74.90) of chlorophyll, while treatment G_1P_0 contain minimum amount (40.30) of chlorophyll. That means, treatment G_3P_2 provide proper growing condition to the plant and also the pond water supply adequate water and nutrient to the plant.

Table 4. Combined effect of growing media and probiotics on chlorophyll SPAD value, number of branches, flower cluster, flowers and fruits per plant of tomato

Treatments	Chlorophyll SPAD value	Number of branches per plant	Number of flower cluster per plant	Number of flowers per plant	Number of fruits per plant
G_1P_0	40.30 d	2.67 e	10.67 c	25.67 f	15.33 e
G_1P_1	45.96 cd	3.34 de	12.00 c	30.00 e	17.34 de
G_1P_2	49.43 bcd	3.67 de	14.33 c	32.00 e	18.00 d
G_2P_0	54.80 abcd	4.33 cd	19.34 b	39.34 d	23.33 c
G_2P_1	63.46 abc	5.34 bc	21.66 ab	47.00 c	28.33 b
G_2P_2	67.83 ab	6.34 ab	22.00 ab	54.34 b	30.67 b
G_3P_0	65.36 abc	5.67 b	19.34 b	48.00 c	25.34 c
G_3P_1	72.50 a	6.34 ab	22.33 ab	57.67 b	30.00 b
G_3P_2	74.90 a	7.33 a	24.00 a	61.33 a	33.66 a
LSD (0.05)	21.33	1.27	4.21	3.61	2.51
CV (%)	20.94	14.91	13.31	4.78	5.94

Here, G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost; P_0=0gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot.

4.4 Number of branches per plant

Statistically, a significant variation was found on the number of branches plant^{-1} of tomato at different growth stages for different growing media composition (Table 3 and Appendix IV). From the experiment, it was observed that growing media G_3 (10% khoa+ 45% cocopeat + 45% vermicompost) produced maximum number of branches (6.44) per plant, while the minimum number of branches (3.22) were observed in G_1 treatment (control) under floating system. The results indicated that number of branches per plant increased with increased level of vermicompost.

Different level of probiotic have showed significant variation in number of branches per plant of tomato (Table 3 and Appendix IV). It was recorded that treatment P_2 (10gm probiotic) produced maximum number of branches (5.78) and treatment P_0 (control) produced minimum number of branches (4.22) in aquavegeculture system. This results indicated that, maximum branches per plant were produced by the application of probiotic comparing with control. That means, plant probiotics helps the plants for proper growth and development.

The combination effect of growing media and probiotics showed significant difference in number of branches per plant of tomato under floating system (Table 4 and Appendix IV). The highest number of branches (7.33) was recorded in G_3P_2 combination which was statistically similar to G_3P_1. And the lowest number of branches (2.67) was recorded in G_1P_0 combination which was statistically similar to G_1P_1. That means, G_3P_2 treatment facilitated proper aeration and helped plant to uptake nutrient from the pond for proper growth and development of plant and resulted maximum number of branches plant^{-1} of tomato.

4.5 Number of flower cluster per plant

The considerable influence was observed on number of cluster per plant of tomato persuaded by growing media at different stages (Table 3 and Appendix IV). Maximum number of cluster (21.89) was produced by media G_3(10% khoa + 45% cocopeat + 45% vermicompost), while minimum number of cluster (12.34) was produced by media G_1(10% khoa + 90% coco peat) under floating system. 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 . This result indicated that the maximum number of cluster was produced by the higher rate of vermicompost than the control, which ensures the optimum growth and development of tomato.

Significant variation was observed in number of cluster per plant of tomato due to the application of different level probiotic (Table 3 and Appendix IV). The P_2 treatment produced maximum number (20.12) of cluster and P_0 treatment produced minimum number (16.45) of cluster per plant of tomato. This result indicated that maximum number of cluster was produced by the application of probiotic compared to control.

The significant variation was recorded in combined effect of growing media and probiotic(Table 4 and Appendix IV). From the data, it was observed that G_3P_2 produced highest number of cluster (24.00) per plant, while G_1P_0 treatment produced minimum number of cluster (10.67) per plant of tomato under floating system. That means, the combination of growing media and probiotic level provide proper growing condition to the plant for their growth and development.

4.6 Number of flowers per plant

Number of flowers per plant of tomato increased gradually with the advancement of growth stage up to the harvest (Figure 5 and Appendix IV). The maximum number of flower (55.67) was recorded from the G_3 treatment compared to G_1 treatment (29.23). The fact that, growing media G_3 provide proper aeration and nutrition to the plant for the advancement of their growing stage under floating system. The result obtained from the present study was similar with the findings of Arancon *et al*. (2003).

Marked variation was observed in the number of flowers per plant of tomato due to the application of different level probiotic (Figure 6 and Appendix IV). The maximum number of flowers (49.23) per plant was found in P_2 treatment and the minimum number of flowers (37.67) found in P_0 treatment.

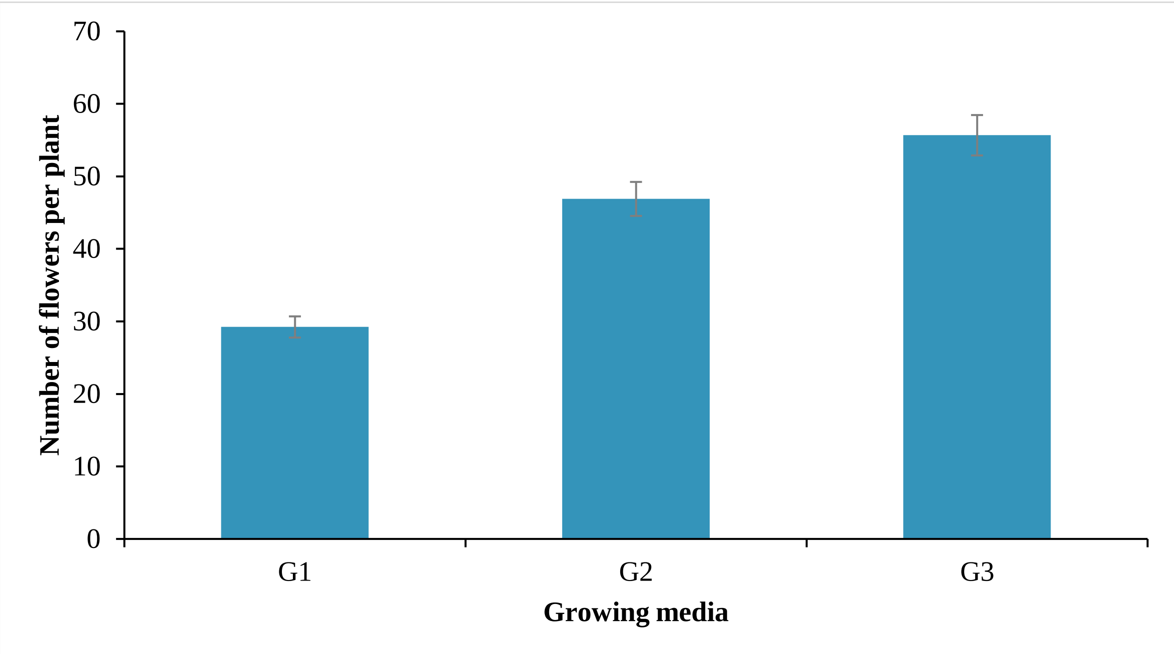

Figure 5. Effect of growing media on number of flowers per plant of tomato

Here, G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost. (Vertical bar represents standard error)

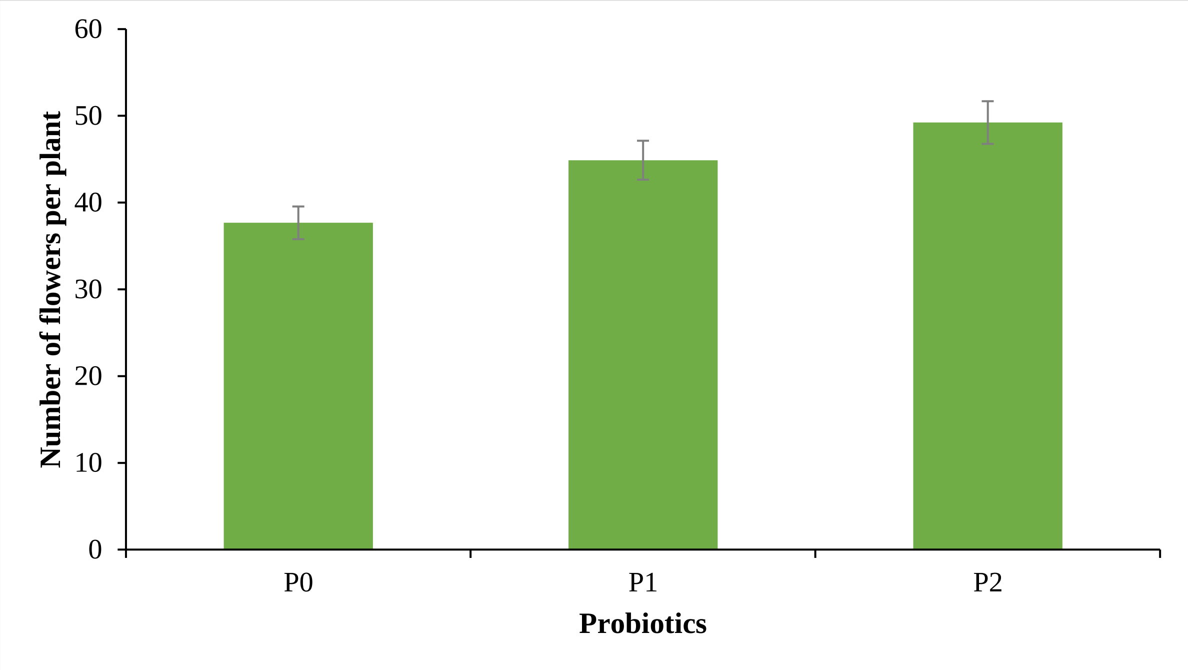

Figure 6. Effect of probiotics on number of flowers per plant of tomato

Here, P_0= 0 gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot. (Vertical bar represents standard error)

A significant variation was observed in flower number of tomato due to the interaction of growing media and probiotic level under floating system (Table 4 and Appendix IV). The highest number of flower (61.33) was recorded from the combined effect of G_3P_2 (10% khoa + 45% cocopeat + 45% vermicompost and 10gm probiotic) which was significantly different from all other treatment combination. The lowest number of flower (25.67) was recorded from the treatment combination of G_1P_0(Control) which was also significantly different from all other treatment combination . The results indicated that growing media and probiotics ensure the optimum condition for the growth and development of tomato and the ultimate result is the maximum number of flower per plant of tomato.

4.7 Number of fruits per plant

In terms of number of fruits per plant of tomato, a statistically significant variation was recorded for different growing media (Figure 7 and Appendix IV). It was observed that, highest number of fruit (29.67) was produced by G_3(10% khoa + 45% cocopeat + 45% vermicompost) treatment, while lowest number of fruit (16.89) was produced by G_1(10% khoa + 90% coco peat) treatment. That means, media G_3 provide proper growing condition to produce maximum number of fruits. Ramirez *et al.* (2014) and Haghighi *et al.* (2016) also found similar results on number of fruits that supported the present findings of the study.

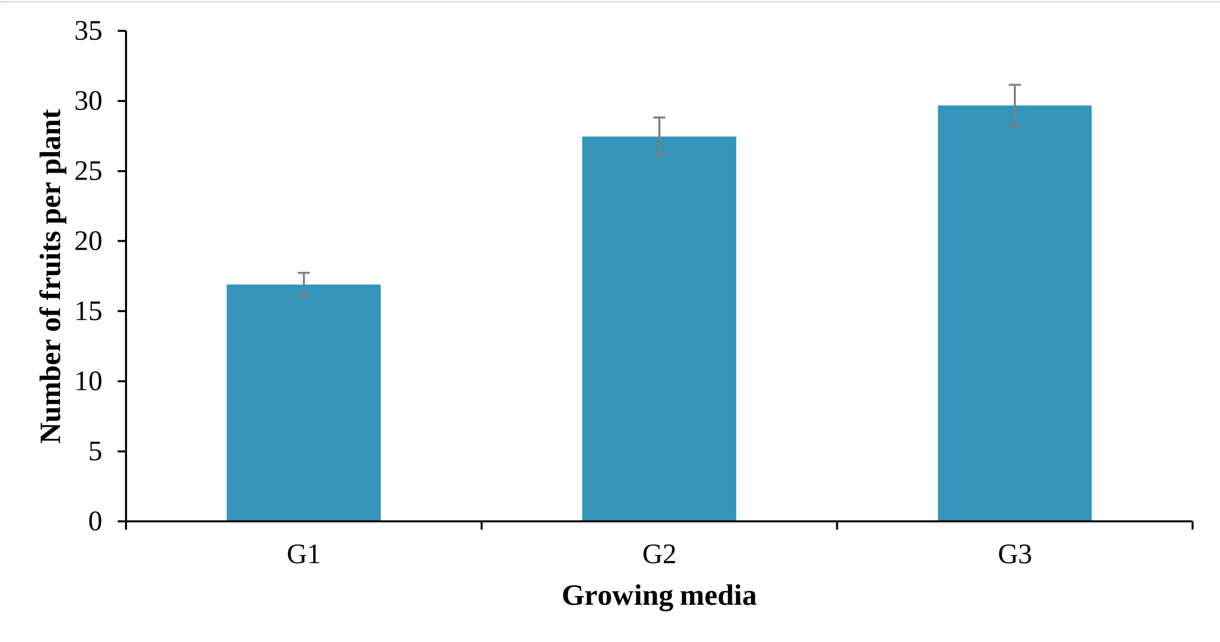

Figure 7. Effect of growing media on number of fruits per plant of tomato

Here, G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost. (Vertical bar represents standard error)

Number of fruits per plant of tomato varied significantly due to the application of probiotic (Figure 8 and Appendix IV) . Maximum number of fruit (27.45) was found in P_2(10 gm probiotic) treatment, whereas minimum number of fruit (21.34) was found in P_0(control) treatment in floating aquavegeculture system.That means, P_2 treatment probiotic performed better than control treatment.

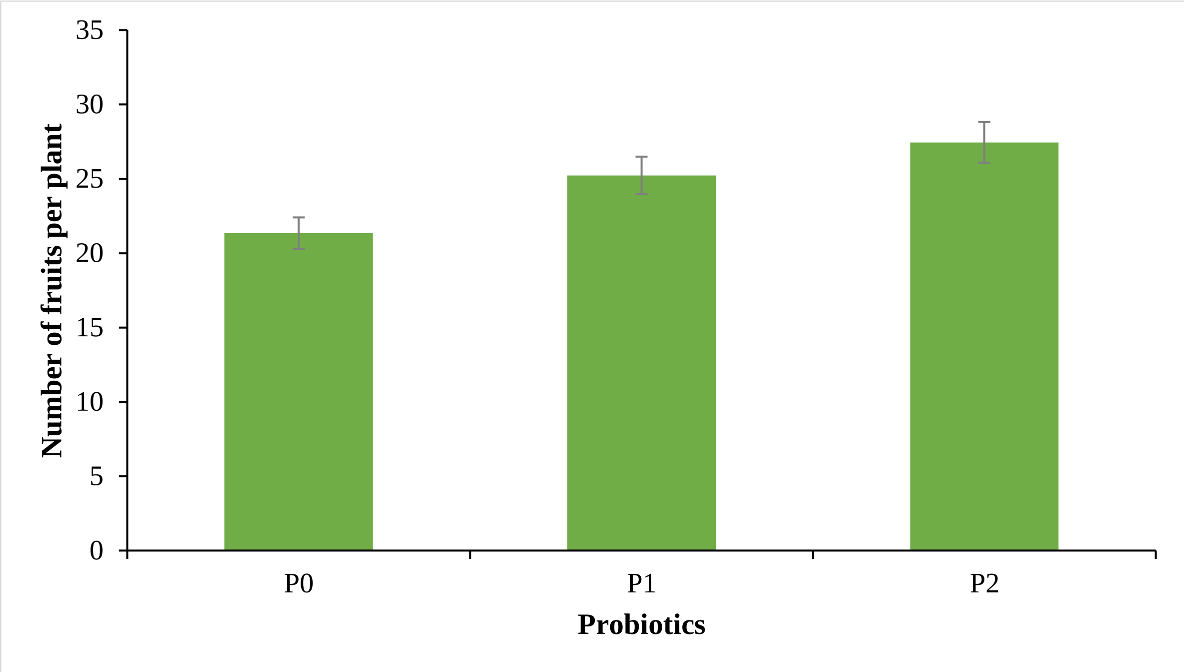

Figure 8. Effect of probiotics on number of fruits per plant of tomato

Here, P_0= 0 gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot. (Vertical bar represents standard error)

The combined effect of growing media and probiotic showed significant difference in number of fruits per plant of tomato under floating aquavegeculture system(Table 4 and Appendix V). Highest number of fruit (33.66) was recorded in G_3P_2 treatment combination and lowest number of fruit (15.33) was recorded in G_1P_0 combination. That means, G_3P_2 treatment facilitated proper condition and helped plant to uptake nutrient for proper growth and development.

4.8 Fruit p^H

The p^H of a fruit is a direct function of the free hydrogen ions present in that fruit which give acid fruits their distinctive sour flavor. Here, there was significant differences was observed in p^H of tomato due to growing media effect (Table 5 and Appendix V). The highest p^H value (4.8) was recorded in G_3 (10% khoa + 45% cocopeat + 45% vermicompost) treatment and the lowest p^H value (4.2) was recorded in G_1 (control) treatment in floating aquavegeculture system. A similar result was also observed by Truong *et al*.(2018), Wang *et al*. (2017) which supported the present study.

The p^H content of tomato fruit showed significant variations (Table 5 and Appendix V) among treatments. The maximum p^H value (4.6) was recorded in P_2 (10gm probitic) treatment and the minimum p^H value (4.4) was recorded in P_0 (control) treatment in floating system. A similar result was also observed by Muhammad *et al*.(2017).

Table 5. Effect of growing media and probiotics on fruit p^H, ascorbic acid content and Brix percentage of tomato

Treatments	Fruit p^H	Ascorbic acid (mg/100g)	Brix (%)
G_1	4.2 c	13 c	3.4 b
G_2	4.5 b	17.91 b	4.5 a
G_3	4.8 a	21.76 a	4.6 a
LSD (0.05)	0.12	1.53	0.27
CV(%)	2.7	8.83	6.71
P_0	4.4 b	15.27 c	3.9 b
P_1	4.5 b	17.64 b	4.2 a
P_2	4.6 a	19.77 a	4.4 a
LSD (0.05)	0.12	1.53	0.27
CV(%)	2.7	8.83	6.71

Here, G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost; P_0=0gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot.

The combined effect of growing media and probiotic showed significant difference in p^H of tomato in floating system(Table 6 and Appendix V) . The highest p^H value (4.9) was noticed from G_3P_2 combination and the lowest p^H value was noticed from G_1P_0 (4.1) combination. That means, G_3P_2 treatment facilitated proper aeration and helped plant to uptake adequate nutrient for proper growth and development. A similar result was also observed by Shen *et al*. (2016) which supported the present study.

Table 6. Combined effect of growing media and probiotics on fruit $p^{H,}$ ascorbic acid content and Brix percentage of tomato

Treatments	**Fruit p^H**	**Ascorbic acid (mg/100g)**	**Brix (%)**
G_1P_0	4.1 d	11.06 g	2.9 d
G_1P_1	4.2 d	13.03 fg	3.6 c
G_1P_2	4.4 c	14.92 ef	4.0 bc
G_2P_0	4.5 c	16.22 de	4.3 ab
G_2P_1	4.6 bc	17.45 cde	4.5 a
G_2P_2	4.6 bc	20.07 bc	4.7 a
G_3P_0	4.7 ab	18.54 cd	4.6 a
G_3P_1	4.8 a	22.45 ab	4.5 a
G_3P_2	4.9 a	24.3 a	4.7 a
LSD (0.05)	0.21	2.65	0.49
CV(%)	2.70	8.83	6.71

Here, G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost; P_0=0gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot.

4.9 Ascorbic acid content

Statistically, significant variation was recorded in fruit ascorbic acid content under the trial for different growing media composition (Table 5 and Appendix V). Results indicated that, the highest amount of ascorbic acid (21.76 mg/100g) was found from the treatment G_3 (10% khoa + 45% cocopeat + 45% vermicompost) and the lowest amount of ascorbic acid (13mg/100g) was obtained from the control treatment G_1 (10% khoa + 90% coco peat).

Different levels of probiotic showed a statistically significant variation in ascorbic acid content of tomato (Table 5 and Appendix V). It was observed that, maximum amount of ascorbic acid (19.77mg / 100g) was recorded from P_2 treatment (10gm probiotic) which was significantly different from other treatments, whereas minimum amount of ascorbic acid (15.27mg / 100gm) was recorded from control treatment P_0.

The interaction effect of growing media and probiotic application showed statistically significant variation in ascorbic acid content of tomato (Table 6 and Appendix V).Results showed that, the highest amount of ascorbic acid (24.3 mg/100g) was found from the treatment combination of G_3P_2 which was significantly similar to G_3P_1 and the lowest amount of ascorbic acid (11.06mg/100g) was obtained from the treatment combination G_1P_0 which was significantly similar to G_1P_1.

4.10 Fruit Brix (%)

Brix is a measure of the total soluble solid content in the tomato or tomato product. Here, there was a significant variation in brix percentage of tomato was observed due to the growing media effect (Table 5 and Appendix V). From the data, the highest brix percentage (4.6) was recorded from the fruit of growing media G_3, while the lowest brix percentage (3.5) was recorded from the fruit of growing media G_1. A similar result was observed by Wang *et al.* (2017).

The effect of different level probiotic on brix percentage of tomato showed statistically significant variations in floating aquavegeculture system (Table 5 and Appendix V). The maximum value (4.5) was observed in P_2 treatment and the minimum value (3.9) was observed in P_0 treatment. A similar result was also observed by Gou *et al*. (2020), Roshni *et al*.(2019).

The combined effect of growing media and probiotic showed significant differences in brix percentage of tomato in floating system (Table 6 and Appendix V).. From the data, the highest brix value (4.7) was recorded in G_3P_2 combination and the lowest brix value was recorded in G_1P_0 (2.9) combination. That means, G_3P_2 treatment combination ensures optimum condition for the growth and development of tomato.

4.11 Fruit length (cm)

Due to different growing media effect, the fruit length showed positively significant differences in tomato (Table 7 and Appendix VI). The highest value of fruit length was recorded in G_3 treatment and the lowest value was recorded in G_1 treatment. Control treatment also showed comperatively better result, might be due to the presence of nutrients in pond water which was uptake by the root system of tomato.

Table 7. Effect of growing media and probiotics on fruit length, fruit diameter and single fruit weight of tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)	Single fruit weight (gm)
G_1	4.16 b	4.64 b	71.22 c
G_2	4.92 a	5.62 a	88.33 b
G_3	5.11 a	5.97 a	106.44 a
LSD (0.05)	0.42	0.38	5.18
CV(%)	9.08	7.24	5.90
P_0	4.43 b	5.03 b	78.22 c
P_1	4.74 ab	5.54 a	89.00 b
P_2	5.02 a	5.66 a	98.77 a
LSD (0.05)	0.42	0.38	5.18
CV(%)	9.08	7.24	5.90

Here, G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost; P_0=0gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot.

The fruit length showed statistically significant impact due to different level of probiotic (Table 7 and Appendix VI).The highest fruit length was recorded in P_2 treatment, while the lowest value was recorded in P_0 treatment. The fruit length was ranges from 4.43cm to 5.03cm.

The combined effect of growing media and probiotic application showed significant differences in fruit length of tomato in floating system (Table 8 and Appendix VI). The highest value (5.46cm) of fruit length was recorded in G_3P_2 combination and lowest fruit length value (3.94cm) was recorded in G_1P_0 treatment combination. That means, G_3P_2 treatment facilitated proper condition and helped plant to uptake nutrient for proper growth and development of plant.

Table 8. Combined effect of growing media and probiotics on fruit length, diameter, single fruit weight and yield per plant of tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)	Single Fruit weight (gm)	Yield per plant (kg)
G_1P_0	3.94 d	4.16 d	63.67 g	0.9 e
G_1P_1	4.26 cd	4.83 cd	72.33 fg	0.98 e
G_1P_2	4.30 bcd	4.94 c	77.67 ef	1.03 e
G_2P_0	4.43 bcd	5.13 bc	80.67 ef	1.37 d
G_2P_1	5.04 ab	5.84 a	86.33 de	1.76 c
G_2P_2	5.30 a	5.90 a	98.00 c	1.85 bc
G_3P_0	4.93 abc	5.80 ab	90.34 cd	1.51 d
G_3P_1	4.94 abc	5.96 a	108.33 b	1.93 b
G_3P_2	5.46 a	6.17 a	120.67 a	2.08 a
LSD (0.05)	0.74	0.68	8.98	0.15
CV(%)	9.08	7.24	5.90	5.61

Here, G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost; P_0=0gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot.

4.12 Fruit diameter (cm)

Impact of growing media on fruit diameter showed positively significant variations (Table 7 and Appendix VI).The highest fruit diameter (5.97cm) was recorded in G_3 treatment which was significantly similar to G_2 treatment, while the lowest value (4.64cm) was recorded in G_1 treatment.

Fruit diameter of tomato differed significantly due to the application of different level probiotic (Table 7 and Appendix VI).Maximum fruit diameter (5.66cm) was observed in P_2 treatment and minimum fruit diameter (5.03cm) was observed in P_0 treatment.That means, probiotic performed comperatively better than control treatment.

A significant variation was observed in fruit diameter of tomato due to the interaction of growing media and probiotic level in floating system (Table 8 and Appendix VI). The highest fruit diameter (6.17cm) was recorded from the combined effect of G_3P_2 (10% khoa + 45% cocopeat + 45% vermicompost and 10gm probiotic), while the lowest fruit diameter (4.16cm) was recorded from the treatment combination of G_1P_0(Control). That means, G_3P_2 combination ensure suitable growing condition for reproductive development.

4.13 Single fruit weight (gm)

The recorded data on a single fruit weight was significantly influenced by different growing media levels (Table 7 and Appendix VI). It was noticed that media G_3(10% khoa + 45% cocopeat + 45% vermicompost) produced highest fruit weight(106.44gm) followed by media G_2 (10% khoa + 60% cocopeat + 30% vermicompost) and the lowest fruit weight(71.22gm) produced by media G_1(control) . This might be due to media G_3 provide best growing condtion and also serves as a reservoir of water and nutrient to the plant. Basheer and Agrawal (2013) and Ramirez *et al.* (2014) supports the present study.

Different level of probiotic have showed significant variation in fruit weight of tomato (Table 7 and Appendix VI).It was recorded that treatment P_2 (10gm probiotic) produced highest fruit weight (98.78gm) and treatment P_0 (control) produced lowest fruit weight (78.23gm).That means, plant probiotics helps the plants for proper growth and development. A similar result was also observed by Muhammad *et al*.(2017).

A significant variation was observed in fruit weight of tomato due to the interaction of growing media and probiotic level in floating system(Table 8 and Appendix VI). The highest fruit weight (120.67gm) was recorded from the combined effect of G_3P_2 (10% khoa + 45% cocopeat + 45% vermicompost and 10gm probiotic), while the lowest fruit weight (63.67gm) was recorded from the treatment combination of G_1P_0(Control).

4.14 Yield per plant (kg)

Yield per plant varied significantly due to the application of different growing media (Figure 9 and Appendix VI). The highest value (1.84kg) of yield was recorded from G_3 treatment and the lowest value (0.97kg) of yield was recorded from G_1 treatment. That means, G_3 treatment (10% khoa + 45% cocopeat + 45% vermicompost) provide proper growing condition and support the plant most compared to G_2 and G_1 treatment. Eswaran and Mariselvi (2016), Azarmi *et al*.(2008) , Arancon *et al*. (2003) and Chaudhary *et al*. (2003) supports the finding of the study .

Different level of probiotic showed significant variation on yield per plant of tomato (Figure 10 and Appendix VI). The maximum yield (1.65kg) was found in P_2 treatment and minimum yield (1.26kg) was found in P_0 treatment. The results indicated that the application of probiotic maximizes the yield per plant of tomato compared to control. A similar result was also observed by Gou *et al*. (2020), Gomez *et al*.(2017) which supported the present study.

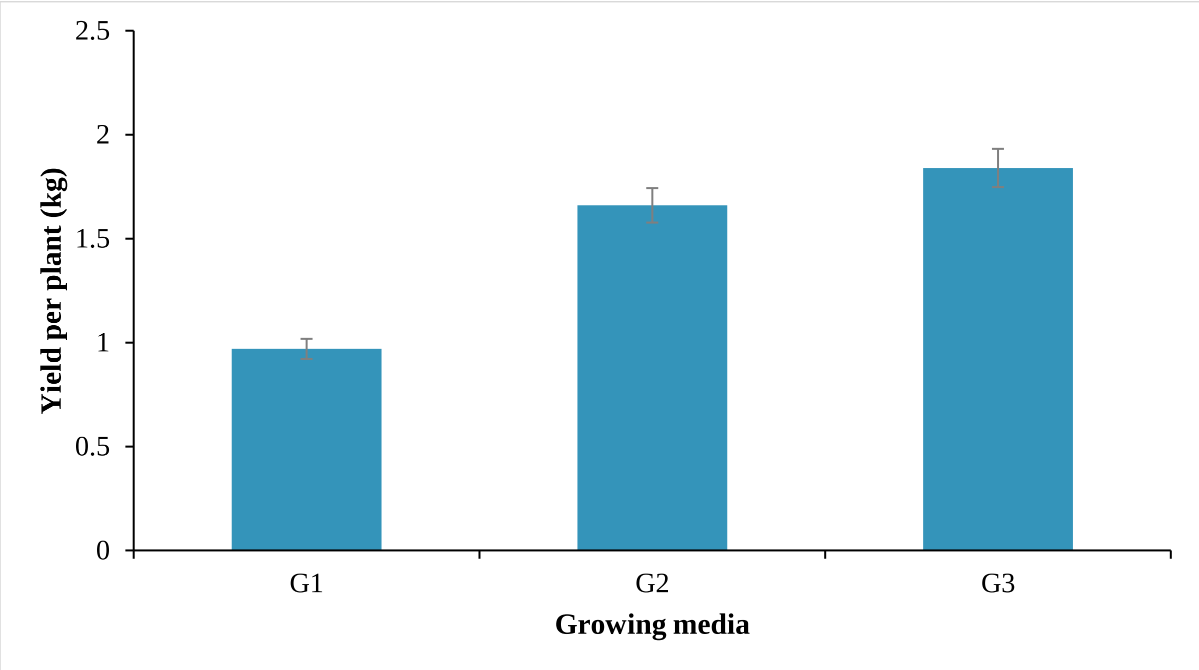

Figure 9. Effect of growing media on yield per plant of tomato

Here, G_1= 10% khoa + 90% coco peat (control); G_2= 10% khoa + 60% cocopeat + 30% vermicompost; G_3= 10% khoa + 45% cocopeat + 45% vermicompost. (Vertical bar represents standard error)

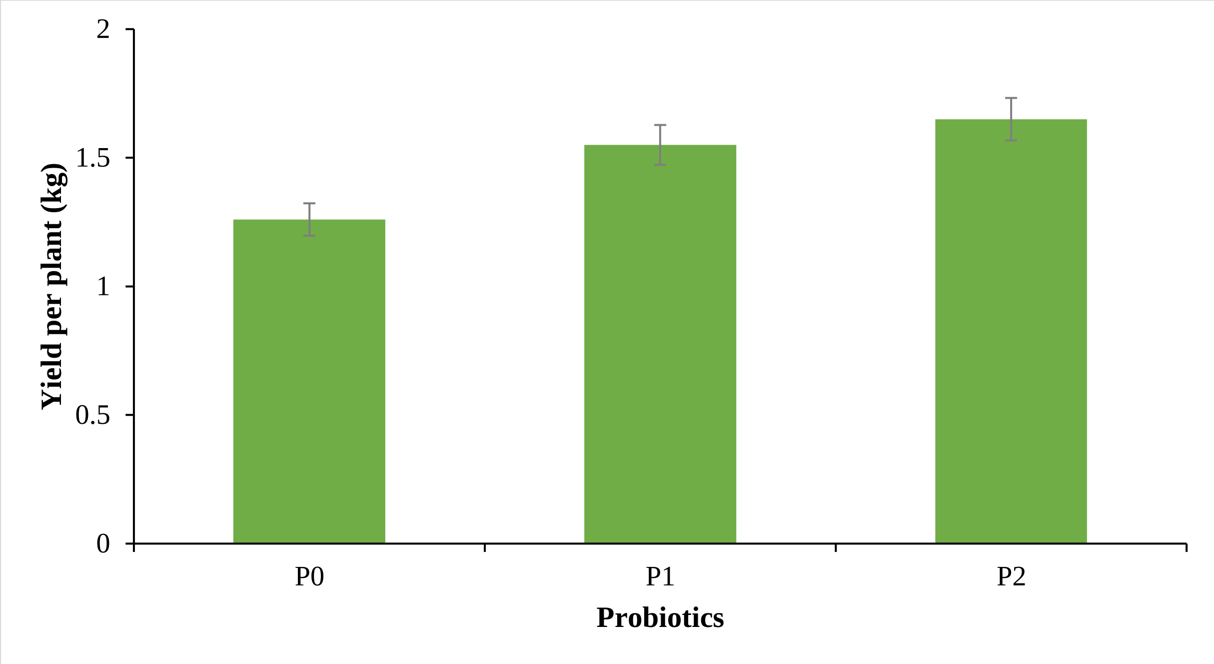

Figure 10. Effect of probiotics on yield per plant of tomato

Here, P_0=0gm probiotic(control); P_1= 5 gm probiotic/pot; P_2= 10 gm probiotic/pot.
(Vertical bar represents standard error)

The interaction effect of growing media and probiotic showed significant differences in yield per plant of tomato in floating system (Table 8 and Appendix VI). From the data, the highest value (2.08kg) of yield was recorded in G_3P_2 treatment combination, while the lowest value (0.91kg) was recorded in G_1P_0 treatment combination. These results indicated that a combination of higher amount of vermicompost with probiotic resulted in maximum yield per plant of tomato compared to no application of vermicompost and probiotic. Almost same result was also observed by Shen *et al.* (2016) .

CHAPTER V

SUMMARY AND CONCLUSIONS

CHAPTER V

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Summary

This experiment was conducted in the horticultural farm of Sher-e-Bangla Agricultural University,Dhaka(Tegaon series under AEZ NO. 28). The experiment was done during the Rabi season from October 2019 to January 2020 to determine the effect of growing media and probiotic on tomato performance in floating system. Two factors were used in this experiment. Factor A: Growing Media such as G_1= 10% khoa + 90% coco peat (control), G_2= 10% khoa + 60% coco peat + 30% vermicompost, G_3= 10% khoa + 45% coco peat + 45% vermicompost and Factor B: Different levels of probiotics such as P_0= 0 gm proiotic(control), P_1= 5 gm probiotic/pot, P_2= 10 gm probiotic/pot. The experiment was laid out in Completely Randomized Design (CRD) having two factors with three replications. Data on growth and yield contributing parameters were recorded and the summary of the results has been presented in this chapter.

Growing media and probiotic had showed significant variation on growth parameters of tomato. From the data, the tallest plant was obtained from G_3(95.24cm), P_2(89.69cm) treatment compared to G_1 (75.06cm), P_0(82.37cm) treatment. The tallest plant was also recorded from the combined effect of G_3P_2 (10% khoa + 45% cocopeat + 45% vermicompost and 10gm probiotic) and plant height ranges from 47.73cm to 99.76cm. While the shortest plant was recorded from the treatment combination of G_1P_0(Control) and plant height was ranges from 36.53cm to 72.05cm. Data also stated that, maximum number of leaves obtained from G_3 (42.00), P_2(41.00) and G_3P_2(44.66) treatment, while minimum number of leaves obtained from G_1 (33.22), P_0(35.77) and G_1P_0(31.33) treatment. Maximum amount of chlorophyll also contain by G_3(70.92), P_2(64.05) and G_3P_2 (74.90) treatment , while minimum amount of chlorophyll contain by G_1(45.23), P_0(53.48) and G_1P_0(40.30) treatment in aquavegeculture system. Maximum number of branches recorded from G_3(6.44), P_2(5.77) and G_3P_2(7.33) treatment, while minimum amount of branches recorded from G_1(3.22), P_0(4.22) and G_1P_0(2.67) treatment. The highest number of cluster found in G_3 (21.89), P_2(20.12) and G_3P_2(24.00) treatment and the lowest number of cluster found in G_1 (12.34), P_0(16.45) and G_1P_0(10.67) treatment.

Significant variation was also observed in yield parameters of tomato due to the application of growing media and probiotic. Data revealed that, treatment G_3(55.67), P_2(49.23) and G_3P_2(61.33) produced maximum number of flower, while treatment G_1(29.23), P_0(37.67) and G_1P_0(25.67) produced minimum number of flower. The highest number of fruits obtained from G_3 (29.67), P_2(27.45) and G_3P_2(33.66) treatment and the lowest number of fruits obtained from G_1(16.89), P_0(21.34) and G_1P_0(15.33) treatment. From the data, maximum p^H value was recorded in G_3 (4.8), P_2(4.6) and G_3P_2(4.9) treatment, while minimum p^H value was recorded in G_1(4.2), P_0(4.4) and G_1P_0(4.1) treatment. The highest brix percentage was obtained from G_3 (4.6), P_2(4.5) and G_3P_2(4.7) treatment and the lowest brix percentage was obtained from G_1 (3.5), P_0(3.9) and G_1P_0(2.9) treatment. From data, maximum fruit weight was found in G_3 (106.44gm), P_2(98.78gm) and G_3P_2(120.67gm) treatment, while minimum fruit weight was found in G_1 (71.22gm), P_0(78.23gm) and G_1P_0(63.67gm). Maximum fruit length and diameter was recorded from G_3(5.12cm, 5.97cm), P_2(5.03cm, 5.66cm) and G_3P_2(5.46cm, 6.17cm) treatment, while minimum fruit length and diameter was recorded from G_1(4.17cm, 4.64cm), P_0(4.44cm, 5.03cm) and G_1P_0(3.94cm, 4.16cm) treatment. So, the highest yield per plant was recorded from G_3(1.84kg), P_2(1.65kg) and G_3P_2(2.08kg) treatment and the lowest yield per plant was recorded from G_1 (0.97kg), P_0(1.26kg) and G_1P_0(0.91kg) treatment.

Conclusions

From the experiment, it might be concluded that both growing media and probiotic had positive impact on the growth and yield parameters of tomato. Among the three treatments of growing media, the highest positive impact was recorded from the plant treated with G_3(10% khoa + 45% cocopeat + 45% vermicompost) treatment compared to G_1(10% khoa + 90% coco peat). Again, among the three treatments of probiotic, the highest positive result was obtained from P_2 (10gm probiotic) treatment compared to P_0(control). In terms of the combined effect of growing media and probiotic, treatment combination G_3P_2 showed the best result compared to G_1P_0. So, it can be concluded that, G_3P_2 treatment combination treated as best among all the treatments.

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APPENDICES

APPENDICES

Appendix I. Monthly records of air temperature, relative humidity and rainfall during the period from october 2019 to march 2020

Year	Month	Air temperature (°C)		Relative Humidity (%)	Total Rainfall (mm)
		Maximum	Minimum		
2019	October	31.2	23.9	76%	52
2019	November	29.2	20.5	67%	9
2019	December	26.4	17	60%	9
2020	January	26	15.3	53%	2
2020	February	29.8	17.4	45%	10
2020	March	34	21.3	48%	25

Source: Bangladesh Meteorological Department

Appendix II. Effect of growing media and probitics on plant height of tomato

Sources of variation	Degrees of freedom	Mean Square of Plant height at		
		30 DAT	45 DAT	60 DAT
Factor A	2	190.674**	536.283**	933.911**
Factor B	2	13.310**	27.681**	120.564**
A×B	4	0.243	6.023**	1.628**
Error	18	2.002	1.045	0.342

** = Significant at 1% level, * = Significant at 5% level

Appendix III. Effect of growing media and probitics on number of leaves per plant of tomato

Sources of variation	Degrees of freedom	Mean Square of Number of leaves at		
		30 DAT	**45 DAT**	**60 DAT**
Factor A	2	101.333**	222.111**	188.926**
Factor B	2	96.778**	84.111**	61.370*
A×B	4	2.778	5.056	3.093*
Error	18	8.148	13.889	20.630

** = Significant at 1% level, * = Significant at 5% level

Appendix IV. Effect of growing media and probiotics on number of branches, clusters, flowers and fruits per plant of tomato

Sources of variation	Degrees of freedom	Mean square of			
		No. of branches	**No. of clusters**	**No. of flowers**	**No. of fruits**
Factor A	2	24.1111**	250.815**	1632.70**	419.444**
Factor B	2	5.4444**	30.704*	306.70**	86.111**
A×B	4	0.2222	1.370	17.93**	7.056*
Error	18	0.5556	6.000	4.41	2.148

** = Significant at 1% level, * = Significant at 5% level

Appendix V. Effect of growing media and probiotics on chlorohyll SPAD value, fruit $p^{H,}$ ascorbic acid and Brix percentage of tomato

Sources of variation	Degrees of freedom	Mean square of			
		Chlorophyll content	Fruit P^H	Ascorbic acid content	Brix percentage
Factor A	2	1532.04**	0.81037**	173.404**	3.45593**
Factor B	2	261.71*	0.09148**	45.494**	0.66926**
A×B	4	3.92	0.01981*	1.661*	0.27037*
Error	18	154.73	0.01481	2.403	0.07926

** = Significant at 1% level, * = Significant at 5% level

Appendix VI. Effect of growing media and probiotic on fruit length, diameter, single fruit weight and yield per plant of tomato

Sources of variation	Degrees of freedom	Mean square of			
		Fruit length(cm)	Fruit diameter(cm)	Fruit weight(gm)	Yield per plant(kg)
Factor A	2	2.24778**	4.29037**	2792.11**	1.87727**
Factor B	2	0.78111*	1.01593**	951.44**	0.37744**
A×B	4	0.10889	0.07370*	65.39	0.04807**
Error	18	0.18481	0.15370	27.41	0.00701

** = Significant at 1% level, * = Significant at 5% level

Plate 1: photograph showing tomato plants growing in the pond