EFFECT OF DIFFERENT COMBINATIONS OF ORGANIC SUBSTRATES ON PLANT GROWTH AND YIELD OF POTATO VAR. DIAMANT CULTIVATED IN CONTAINER

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ABSTRACT

In order to study the effect of different combinations of organic substrates on plant growth and yield of potato var. Diamant in container, an experiment was conducted as one factor Completely Randomized Design with 5 replications in the Addhapak Purnendu Gein Field Laboratory of Agrotechnology Discipline of Khulna University from December 2013 to April 2014. Water hyacinth and vermicompost were combined with soil in different ratios and form eleven treatments including control. The treatments were T_0 (100% soil), T_1 (100% water hyacinth compost), T_2 (50% soil with 50% water hyacinth compost), T_3 (50% soil with 50% vermicompost), T_4 (50% water hyacinth compost and 50% vermicompost), T_5 (75% soil with 25% water hyacinth compost), T_6 (75% soil and 25% vermicompost), T_7 (75% water hyacinth compost and 25% vermicompost), T_8 (75% vermicompost and 25% water hyacinth compost), T_9 (25% soil with 50% water hyacinth compost and 25% vermicompost) and T_{10} (50% soil with 25% water hyacinth compost and 25% vermicompost). It was revealed that organic substrates had significant effect on the growth and yield performance of potato plant compared to the control treatment. The treatment T_8 (75% vermicompost and 25% water hyacinth compost) produced maximum number of tuber and T_7 (75% water hyacinth compost and 25% vermicompost) gave the highest tuber length, breadth and weight of tuber per container and T_7 also provided maximum gross return among the all treatments. But maximum net income and benefit cost ratio (BCR) were found in T_1 (100% water hyacinth compost) while negetive result of BCR was recorded from remaining treatments except T_1, T_2 and T_5. This difference was found from variation of production cost. Finally it can be summarized that 100% water hyacinth compost was economical and beneficial for production of potato in container.

Dedicated

To

My Beloved Parents

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CHAPTER- I

INTRODUCTION

Potato (*Solanum tuberosum* L) is an herbaceous plant belongs to the Solanaceae family. It is one of the world's most important tuber crops. It ranks as fourth after rice, wheat and maize based on its consumption (FAO, 2012). It is originated from the Andes cordillera in South America.

Potato is a staple food in many countries most commonly in Europe and it is used as vegetable in Africa and Asia, especially in Bangladesh. Potato represents about 53% of the total edible vegetables in Bangladesh (Mahmood, 2005). This tuber crop is rich in carbohydrate and proteins of superior quality. It contains vitamins and minerals and potassium but it is nearly fat free. Thompson and Kelly (1972) termed potato as one of the world leading vegetable crops and cheapest source of carbohydrates and furnishes appreciable amount of vitamin B_1 and C.

It is grown from sea level to 13,000 feet above. The top countries for potato production are China (72 Mm t per year), the Russian federation (37 Mm t per year), India (26 Mm t per year), the United States (20 Mm t per year) and Ukraine (19 Mm t per year) (FAOSTAT, 2012). In Bangladesh potatoes are widely cultivated as one of the major vegetable crops. But commercially it is produced largely in the districts of Dhaka, Rajshahi, Dinajpur, Rangpur, Bogra and Mymensingh. Of the early crop about 80% is raised in the northern districts and 20% in the highlands of Munshigonj, Comilla and other areas of the country. The highest number of potato produces from Munshigonj (Amanullah *et al.*, 2010).

The soil which is loose, well-drained and high in organic matter is ideal for potato cultivation. In addition, potatoes thrive profusely on soil with large quantities of both nitrogen and potassium and it loves acid conditions pH as low as 4.8. Potatoes are normally planted in November for harvesting throughout winter and summer. For local variety they can also be planted in mid October to mid November (Hossain *et al.*, 2009).

In other word potato requires cool temperature and sandy loam soil. In Bangladesh potato is usually cultivated by tuber as planting material. About 1 to 2 tons of seed tubers are needed to plant one hectare of land. Potato cultivation requires judicious application of water and fertilizers. Chemical fertilizers as urea 220-250kg, TSP 130-150kg, MoP 230-250kg, Gypsum 110-130kg, Zinc sulphate 12-16kg and Boric acid 5-7kg are recommended for one hector of land area (Hossain *et al.*, 2009). These fertilizers meet the nutritional requirement of potato. But organic fertilizer can be used as substitute of chemical fertilizers like vermicompost, water-hyacinth, farm yard manure etc. The moisture content of vermicompost ranges between 32 and 66% and the pH is around 7.0. The worm castings contain higher percentage of both macro and micronutrients than the garden compost (Nagavallemma *et al.*, 2004).

However potatoes are cultivated in field condition but this can also be grown in container, plastic pots or bags. This cultivation technique is suitable in a situation where land is not available or where land scarcity present. In this technique, container or bag contains growth medium which hold moisture and supply essential elements to the plant required for growth and production.

Although potatoes produce more in the Northern region of Bangladesh, in the area near coastal region potatoes are not generally cultivated. If cultivated, then in very small scale. This situation occurs due to land scarcity, land unavailability and salinity problem. Most of the farmers in this area are land less or marginal farmer. They have no or small amount of land and they are interested to grow Aman rice or culturing shrimp during the period which is the appropriate time for potato cultivation. As well as land suitability for potato cultivation in this coastal region is meager. As the area is relatively low lying, Aman rice is cultivated in kharif-II season.

Due to the climate change, Aman rice growing has been shifted which overlap with the potato growing season. So it is not possible to cultivate potatoes after harvesting of Aman rice. On the other hand, sometime land for potato cultivation may be available but farmers do not want to take a risk of potato production due to the presence of high salinity. In this situation, the people of this area can cultivate potato in pots or bags in small scale for their family consumption. They can use the extra bags of fertilizer or cement or bazaar bags for the purposes and then the cost can be minimized.

The poor and distressed women can cultivate potato in this system in their homestead areas even in the side of the river embankments or roadside. In this way they can fulfill their own requirement of potato.

On the other hand, interested people in the urban area can produce potato in pots on the roof top their houses. It can increase the production of potato as a whole and contribute to the food security and food safety.

Again, day by day, the use of chemical fertilizers is increasing in Bangladesh. But the production of farmer is not increased with the increased application of chemical fertilizer in some casees. Sometime applied fertilizers are leached to ground water or runoff to the surface water. Then chemical fertilizers pollute water as well as environment. Soil degradation also takes place for the use of chemical fertilizers that hamper soil productivity. As a consequence, crop productivity stagnant or decline which have threaten the sustainable agriculture. Inorganic fertilizer not only pollutes environmental factors but also causing harm to human health. When organic substrates are used in place of chemical fertilizers then environmental pollution and other problem arise from chemical fertilizer are minimized.

To mitigate this production problem of potato, it can be grown in pots or bags which containing organic growth media. These organic materials are of low cost, easily available but contain sufficient nutrients that can promote growth and production. Through combination of one or more organic matter growing medium can be made more appropriate. Now a day, people have been suffering from hazardous effect of chemical fertilizers and they show their eagerness to the organic product. In this case these types of cultivation may be considered as time demanding. Family member can take care of small scale potato cultivation in containers. All the management practices and harvesting procedures are simple and manageable in container production than field condition. This method of potato cultivation requires less space along with less production cost.

Considering above discussion the present study was conducted with the following objectives-

Objectives

- To find out the best combination of organic substrates for small scale potato cultivation in container.
- To analysis benefit cost ratio.

CHAPTER- II

REVIEW OF LITERATURE

In this chapter different studies on potato production and their performance on different growing media are discussed. Beside these, effects of different organic matter on vegetable production are also given.

2.1. Techniques and their effects on performance of potato

Traditional method of potato production is ridge and furrow method where potato seeds are planted within the ridge (Chowdhury and Hassan, 2013). In the field condition for the continuous cultivation of land soil become compact and soil structure are damaged and then root growths as well as tuber formation are hindered. On the other hand, potato plants compete with weed and insect and diseases easily attack the plant from nearby alternate plant. Beside this traditional method potatoes are also produced using other techniques like hydroponic, aeroponic where nutrients are artificially supplied (Mbiyu *et al.*, 2012 and Correa *et al.*, 2009). Correa *et al.* (2009) revealed that hydroponic are more efficient over traditional potato production technique as its production rate was three times greater than traditional method and according to Nistor *et al.* (2009) hydroponics has proven to be a very successful strategy for the production of seed potatoes for the adequate supply of nutrients to plants. Aeroponic techniques allowed larger numbers of tubers production and potato seeds production due to the good root aeration, proper nutrient supply and uniform and less water uses efficiency. From the study, it was found that light condition leads the stolon to stem formation instead of tuber formation as darkness are not properly maintained and this techniques was most costly (Mbiyu *et al.*, 2012).

When the plant is grown in pot or container then it is called pot culture. Generally pot culture are practiced in green house and in tissue culture technique and in most of the cases ornamental plant are grown on pot or bag or container (Rout *et al.*, 2006). Some vegetables are rarely and luxuriously cultivated in container on roof top where most of the case potato cultivation is absent. Tomato belongs to the same family of potato was grown in greenhouse within the pot to improve yield and cost efficiency of production using different treatment where plant performed good (Mabengwa, 2013). The production per cultivated unit area of greenhouse tomatoes can be in excess of 50 kg/m^2 which are 10 times superior to that of field crops (Canadian encyclopedia, 2010). When only field soils are used in container then it become unsatisfactory for the production of plant because soils do not provide the aeration, drainage and water holding capacity required for plant and for this reason different materials like peat, bagasse, coconut fiber (Cocus), straw, sawdust, calcine clays, rice hulls and leaf molds have been used (Wilkerson *et al.*, 1994). From the statement of Conover and Joiner (1963) labor, production and sales area were more efficiently utilized in container growing system. For the better control of environment and cultural practice planting season could be extended and supply mineral matter also could be maintained.

2.2. Effect of water hyacinth

Based on recycling of waste and as composting is safe form of treatment water hyacinth was used as growing medium. In that experiment water haycinth and neem based compost were used to evaluate growth, fruit yield and quality of cucumber where combined effect of neem and water hyacinth gave good growth of vine (132.67 cm), vine girth (2.77 cm) and increased leaf area (241.37 cm^2), number of leaves (33 leaves per plant), as well as fruit yield (142.6) per plant. This result might be due to the good water holding capacity and increased nutrient supply to the plant as organic matter increase beneficial microorganisms which break down organic matter to create humus. On the other hand water hyacinth and neem provided favorable effect for vegetative growth and contained particularly Fe, Zn and Mn enhanced flowering and fruiting leading to an increase in early fruit maturity (Adesina *et al.*, 2011).

Another experiment of water hyacinth with farm yard manure on coriandrum was carried out by Lata and Dubey (2013) and result revealed positive response with 100% water hyacinth manure, 50% water hyacinth manure and water hyacinth manure combined with farm yard manure on the growth behaviour of seedlings where seedling growth rate was increased in that combination than the control. The growth and production was more distinctive with 100% water hyacinth manure treatment. Majid (1983) have reported yield plant^{-1} in rice, corn, sesame, brinjal, onion and gourd were enhanced using Water hyacinth compost and Gunnarssen and Petersen (2006) also highlighted that using composted Water hyacinth material could serve as quality manure for improving soil fertility conditions and thus crop yields on the whole. Vidya and Girish (2014) also studied on effect of water hyacinth compost on wheat production and that experiment also provided higher values of physical (percentage of germination (88%), length of shoot (15.99cm), length of root (14.75cm), root and shoot ratio (0.922cm) and biomass content) and chemical parameters (chlorophyll content (11.15 mg/g), protein content (0.31mg/g) and reducing sugar content (0.72mg/g)) compared to control.

Enhanced affects of Water hyacinth have been reported by Kayum *et al.* (2008) on productivity of tomato. But the experiment of Mashavira *et al.* (2015) not exactly support the idea of Kayum *et al.* (2008) because they told that water hyacinth compost positively improves the growth rate and yield of tomatoes without compromising the health of consumers by heavy metal toxicity builds up but the water hyacinth compost rate does not have significant influence the number of fruits per plant. This might be due to the high nitrogen production from compost that leads to more vegetative growth than reproduction. Beside this when water hyacinth used as mulch then it also influenced vegetative growth and reproductive yield of tomato plant significantly under saline condition (Saeed and Ahmad, 2009).

In potato production water hyacinth was used as mulches with or without other products. From the study of Jalil *et al.* (2004) it was found that two varieties of potato named Cardinal and Lal pakri provided maximum yield under water hyacinth mulch and they concluded the water hyacinth mulch as economically best mulching treatment. Razzaque and Ali, (2009) also used water hyacinth and rice straw as mulch for cultivation of five varieties of potato (Heera, Dhera, Diamant, Chamak and Cardinal) where Heera produced highest yield under water hyacinth (23.15 t/ha) mulch and other varieties shown more or less similar result. Both of the case water hyacinth shown better performance and it might be due to their nutrient release. Rautaray (2010) conducted three experiment using water hyacinth and paddy straw where second experiment gave higher potato yield than tomato on water hyacinth than first experiment and this variation was occurred because 2nd experiment used dried hyacinth while 1st one used more moisture containing materials.

From the discussion made above it is revealed that water hyacinch was used as mulch in most of the case of potato production but it was not used as growing medium for potato. But it has capacity to supply nutrient that increase plants vegetative growth and shown good performance on reproduction. After studying that water hyacinth was selected for potato production as growing medium.

2.3. Effect of vermicompost

As one of the best waste recycling method composting improves soil fertility and reduces environmental pollution. Vermicompost is one of the organic manure that has been used in agriculture for its valuable nutrients and inorganic form (Vijayalakshmi *et al.*, 2006). Mineral content of vermicompost are N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu and B and those improve plant nutrition as well as nutrient status of different plant parts like roots, shoots and fruits, increase photosynthesis rate and the chlorophyll content of the leaves. Beside this it contains humic acids which are necessary for plant health to synthesis phenolic compounds such as anthocyanins and flavonoids. These phenolic compounds improve plant quality and act as insect repellent and disease deterrent (Theunissen *et al.*, 2010).

Dhanalakshmi *et al.* (2014) carried out an experiment on the vegetable production using vermicompost where germination percentage of the seeds of okra, brinjal and chilli were 96.74, 84.32 and 92.35 while grown in 50% vemicompost containing soil and tomato also sown higher germination percentage. Beside these root length of okra and chilli and shoot length, branch number and leaf number of okra, chilli, brinjal and tomato were high in vermicompost containing soil.

Ansari (2008) conducted an experiment under field condition to observe the effect of vermicompost on productivity of three vegetables potato, spinach and turnip using three doses (4, 5 and 6 tonnes/ha) of this compost. In that experiment overall productivity of vegetables was greater with high dose of vermicompost (6 tonnes ha^{-1}) application and potato and turnip required higher vermicompost than leafy vegetables spinach. For this type of variation he reclaimed that leafy vegetables require lesser macronutrient and uptake lesser, on the other hand potato and turnip require higher as well as absorb higher macronutrient.

From this study it also found that vermicompost significantly improve soil quality and increase availability of food for crops.

In case of cucumber, 14 tonnes /ha vermicompost helped to produce highest fruit yield and fruit weight. It was 24% more yield than chemical fertilizer and that result was higher than all other treatment (cow manure, urban waste compost and marian algae spray) of the experiment. Beside this, vermicompost also increased plant dry weight as well as plant root's dry weight (Ghasem *et al.*, 2014). Nitrogen content of vermicompost (nitrogen content more than other composts) caused more meristem and more cell division to induce better plant growth and development (Tisdale and Nelson, 1975). On the other hand vermicompost increased soil porosity and reduce bulk density which leads to better root growth and well developed root system which enhanced above ground growth and development that result in higher yield (Ghosh *et al.*, 2004). Dynes (2003) supported the result of Ghosh *et al.* (2004) and explained that vermicompost in decreased soil bulk density produced growth promoting hormone that causes better root network of plant. Plant efficiency was increased by vermicompost and again this compost was also effective when it was mixed with top soil (Haug, 1993 and Danys, 2003). Finally Ghasem *et al.*, (2014) draw a conclusion and which was that vermicompost supply more plant nutrient and improve soil physical condition that facilitate better plant growth and yield.

Combined application of vermicompost with NPKS influenced the growth and yield of potato and 100% inorganic fertilizers with 5-10 t ha^{-1} of vermicompost is suitable for better production of potato where plant height, number of main stem/hill, weight of haulm, yield of haulm, dry weight of haulm, number of tubers/hill and percentage of dry matter of tubers were more or less positively and significantly responded to the vermicompost but use of

100% vermicompost was not economical (Alam *et al.*, 2007). In this study dry matter accumulation in plant and tuber were increased with the application of vermicompost and inorganic fertilizer.

From the study of Bahrampour and Ziveh (2013) it was observed that vermicompost increased growth and yield of tomato and beside this dry matter content of fruit and K, P, Fe and Zn content of plant tissue increased 24, 55, 73, 32 and 36%, respectively in vermicompost treated plant compared to untreated one and best performing amount was 15 tonnes/ha. So enhanced growth and yield of tomato might be due to greater uptake element nutrients such as P, K, Fe and Zn, organic matter mineralization, decreased of soil pH by organic acids produced in vermicompost and increases micronutrient complexes formation. But excessive vermicompost reduced number of fruit by providing suitable condition for physiological disorder blossom end rot. But from another study it explained that decline in numbers of fruits having blossom-end rot symptoms with adding of vermicompost could probably be due to increases in Ca uptake by plant (Aggelides and Londra, 1999). When experiment was conducted on pepper then also significantly positive result was found in the case of leaf areas, plant shoot biomass, marketable fruit weights and decreased loss of yields. Growth and yield of pepper might be increased due to humic materials and other plant growth-influencing substances, such as plant growth hormones produced during vermicomposting by microbes (Arancon *et al.*, 2005).

From the above study it is clear that vermicompost contains different mineral elements, provide phenolic compound and growth enhancing substances and increase soil porosity and improve physical properties. Different kinds of vegetables grow and perform well in the vermicompost mixing growing medium.

2.4. Effect of other organic materials on yield and yield components

Potato crops require larger quantity of fertilizers (Islam *et al.*, 1980). For successful production of potatoes, proper use of fertilizer and manure is essential. Organic manure increases soil organic matter supplies essential nutrient elements for plants. Organic manures like cowdung, compost, farmyard manure and green manure supply more or less complete food for plants (Ahmed, 1982).

A study was conducted by Baniuniene and Zekaite (2008) to estimate the effect of organic (farmyard manure) and mineral fertilizer combinations on potato tuber yield and quality where farmyard manure (FYM) increased potato tuber yield by 35 - 82 %. The highest tuber yield increases (3.8–6.0 t ha-1) were obtained from fertilizer combinations with nitrogen and only mineral fertilizer gave more starch (184.5g/kg) and dry matter (247.7g/kg) in tuber than farm yard manures.

In Abou-Hussein (2002) experiment it was observed that potato produce increased result in plant height, total yield, fresh and dry weight of leaves and stems when grown with chicken manure + compost + biofertilizer than other treatment.

Kaur and Singh (2001) conducted an experiment with potato to know the effects of inorganic and organic (farmyard manures) manure on yield and yield attributes and reported that chemical fertilizers along with farmyard manure increased potato yield than absolute application of chemical fertilizers.

Okonkwo and Lanq (2003) found that half dose of NPK and half dose of poultry manure or cowdung significantly increase yield of potato than control or other treatment where poultry manure; cow dung and inorganic fertilizer NPK in different combination were used as treatment in Nigeria during 1998. Asmus and Gorlitz (1986) observed that combined application of FYM and mineral fertilizer increased potato yield. Ilin *et al.* (1992) also observed that application of mineral fertilizers and FYM increased tuber yield by 43-45.3%. Nicola and cardinal two potato varieties were used on a experiment under single or mixed application of inorganic fertilizer, poultry manure and/or cowdung where poultry manure out yielded over cowdungin both varieties (Ifenkwe *et al.*, 1987). Banerjee and Singhamahapatra (1986) studied on the effect of NPK fertilizer along and in combination with cowdung and/ or poultry manure on potato growth and yield and observed result was that potato growth and tuber yield were good on poultry manure with inorganic fertilizer. When only organic fertilizers like manure, spring barley straw and mustard straw were used for potato production then potato produced highest yield on manure but more dry matter content was found from mixture of straw and manure (Boligowa and Glen, 2003).

Potato plant produce optimum tuber yield of 27.1 tonnes/ha was obtained from peat manure with inorganic NPK (Zavalin *et al.*, 1993). But from the study of Mondal and Mazumdar (1986) it was investigated that significantly higher number of tuber were produced in the composition of FYM with inorganic NPK. Here most of the best results were found from joint contribution of organic and inorganic fertilizer. But now present study is conducted only with organic substrates for potato production to investigate the performance of plant in organic matter.

It is revealed from the above review of literature that the work on the effect of different combinations of organic substrates on plant growth and yield of potato cultivated in container is meager in respect of Bangladesh as reported by different authors. So, the present study was under taken.

CHAPTER- III

MATERIALS AND METHODS

In this chapter the details of different materials used and methods followed during the experimental period are presented under the following sub-heads:

3.1. Location of study

This study was carried out in the Addhapak Purnendu Gein Field laboratory of Agrotechnology discipline of Khulna University, Khulna during the period from December 2013-April 2014 which consisted the season from winter to summer.

3.2. Materials of the study

3.2.1 Selection of potato variety

BARI released potato variety BARI Alu-7 (Diamant) was used in this experiment. This variety is short duration crop (90-95 days) with white skin, oval to oblong shaped, medium to large size, smooth skin, light yellow flesh and shallow eye. The 5 kg of potato tuber for planting were collected from Regional Agricultural Research Station (RARS) of Jessore.

3.2.2 Preparation of potato tuber for planting

Healthy, vigorous, disease free and larger sized seed potatoes were selected for chitting process which encouraged to sprout from eye of tuber under warm and humid condition before planting. For this task dry hay were collected from farmers field and spread on the floor under less light place and then dry clean tuber placed on the dry hay. After keeping the tuber in dry hay, it was covered with gunny bag and then little amount of water was applied over it which made the environment within gunny bag warm and humid. That condition was favorable for chitting and after 3 days water was applied to maintain that condition till sprouting. At 3-5 days white color and very small sized sprout came out and after 7 days all seed potato were properly sprouted and more than two sprouts were developed from each tuber.

3.2.3 Collection and preparation of soil

Soil was collected from the site of Gallamari near the Khulna University. At the time of bringing soil was wet and then it was dried for 7 days. When soil dried then clods were broken with spade and dumble. All unwanted materials, weeds and stubbles were removed from the soil and made loose and friable. Potato grows well in sandy loam soil but soil was loamy and 2.5 bucket of sand was added to collected soil to make it sandy loam. Then pH and electrical conductivity of the soil were measured from the soil chemistry laboratory of Agrotechnology discipline of Khulna University. From the test, it was found that soil was neutral where pH was 7.2 and ECE was 286.8 microsimen per meter. Then soil was prepared for experiment and 255 kg soil was used in study.

3.2.4 Preparation of substrates

For conducting experiment vermicompost and water hyacinth including soil were used as substrates. Vermicompost was collected from Plant Breeding and Biotechnology Laboratory, Agrotechnology Discipline of Khulna University and 82.5 kg compost was required for the experiment. The composition of vermicompost is given in Appendix I.

Water hyacinth was plucked from the Lake of Khulna University and dried in the sun for 10 days to reduce its heavy water conservation. These matters were turned every 2 to 3 days to dry properly and total amount of water hyacinth was 84 kg. Compositions of water hyacinth are given in the Appendix I.

3.2.5 Collection of bags

In this experiment 55cm length and 40 cm width bazaar plastic bags were selected as growing container and those bags were bought from Gallamari bazaar. Sixty bags were bought to avoid flawed bag. Instead of plastic pot or earthen pot plastic bazaar bags were chosen for their porous textures that facilitated good drainage condition.

3.3. Experimental design and treatment

3.3.1 Experimental design

One factor experiment was laid out in a CRD where one variety was used with eleven treatments and five replications. Experiment was carried out in bag in open space, so effect of environmental factor could not be controlled but growth of the root was confined into the bag and for this reason experiment was setup in a Completely Randomized Design where each of the bags represented one treatment.

3.3.2 Treatments

Those treatments were follows:

T_0= 100% loamy soil (control)

T_1=100% water hyacinth compost

T_2= 50% soil with 50% water hyacinth compost

T_3= 50% soil with 50% vermicompost

T_4=50% water hyacinth compost and 50% vermicompost

T_5= 75% soil with 25% water hyacinth compost

T_6= 75% soil and 25% vermicompost

T_7= 75% water hyacinth compost and 25% vermicompost

T_8= 75% vermicompost and 25% water hyacinth compost

T_9= 25% soil with 50% water hyacinth compost and 25% vermicompost

T_{10}= 50% soil with 25% water hyacinth compost and 25% vermicompost

3.4. Bag filling and planting of sprouted potato

Bags were filled with soil and different combination of substances at the height of 10 inch. Potato plant produces potato at the depth of 8 inch from the top level of soil and considering this bag was filled with treatment at that height. When filling was done then whole bags were soaked with water and in the next day media were turned with rake. On the other hand, chitted tubers were removed from ghanny bag and cleaned the hay. Then each tuber was cut into more than 3 pieces with sharpe and clean knife keeping on hard board and every piece of tuber contained vigorously growing sprout. Some tubers with blackish color flesh were discarded to evade seed born disease. After cutting of tuber sprouted tuber pieces were planted within the treatment containing bag. Two pieces of propagating materials were placed at the depth of 3 inches. Immediately after planting it was covered with soil and planting was done at 14 December 2013.

3.5. Intercultural operation

3.5.1 Irrigation

After emergence the crops were irrigated lightly to moisten the substrate and some sowing sprouts were delayed to grow as plantlets and those were also soaked with water. To ensure uniform growth and development all the plants were watered every 7 days after emergence of potato seedling and it continued throughout the whole crop period.

3.5.2 Weeding and earthing up

Some weed seeds were germinated in the bags and at the latter stage of experiment some *Cynodon dactylon* were grown in bags from ground soil penetrating through porous bags. All those weeds were easily eradicated through hand weeding. Experiment was carried out on bag so earthing up was not applicable in the crops.

3.5.3 Plant protection measure

At early stage some plants were affected with potato virus y (PVY) which were uprooted and destroyed. Imitaf of imidachloripid group was applied at the rate of 0.5 ml per liter to control white fly population vector of virus transmission. That insecticide was sprayed three times at 15 days interval from 28 DAP to 58 DAP. To control early blight of potato Greenzel 72WP of Mancozeb 68% + Metalexil 8% group was sprayed three times at 15 days interval at the rate of 0.25g/liter.

3.6. Harvesting

Harvesting was done at different days which started from 90 DAP to 104 DAP. After harvesting every harvested plant and yield was tagged bag wise and yield was measured in gram per bag.

3.7. Data collection

The following parameters were recorded and their mean values were calculated from the sample plants.

a) Time of emergence: Time of emergence was measured from the date of planting to the date of emergence.

b) Duration of crops: This parameter was measured by counting the day from time of emergence to time of harvesting.

c) Plant height: Plant height was measured from base of the plant above the soil surface to the tip of the plant using centimeter scale at 15 days interval. For plant height 5 times data were measured and data collection was started from 27 days after planting (DAP).

d) Stem diameter plant^{-1}: Stem diameter was measured using digital slide calipers at 15 days interval and average value of two plants was recorded in milimeter.

e) Number of leaves plant^{-1}: Every 15 days interval number of leaves per plant was counted which starting from 27 DAP to 82 days after planting and mean value was calculated.

f) Leaf length, leaflet length and leaflet breadth: All these parameter were measured using centimeter scale at 15 days interval. For recording data three leaves from middle portion of the plant were selected and 4 times data were collected.

g) Leaflet number plant^{-1}: Leaflet number of three selected leaves of each plant was counted and then average leaflet number of two plant of each bag was calculated.

h) Number of main stem plant^{-1}: The number of main stem per plant was calculated from the average of two plants per bag.

i) Weight of tuber and fresh weight of plant: All these plant materials were weighted separately using digital weight machine and then data of those parameters were measured by averaging the data from two plants per bag.

j) Number of tuber: Tuber number was measured by averaging the tuber from two plants.

k) Tuber length and breadth: The length and breadth of the tuber was measured using slide calipers and millimeter unit was used.

3.8. Statistical analysis

Data were collected based on different parameters and were analyzed statistically following the analysis of variance (ANOVA-1) technique and the mean differences were adjudged by Duncan's New Multiple Range Test (DMRT) using the statistical computer package program MSTAT-C (Gomez and Gomez, 1984).

3.9. Benefit cost ratio

Benefit cost ratio is an indicator, used in the formal discipline of cost benefit analysis that attempts to summarize the overall value. The most profitable treatment combination was found out by analyzing cost of production. Benefit cost ratio was calculated by following formula:

$$\text{Benefit-cost ratio} = \frac{\text{Gross return}}{\text{Total cost of production}}$$

CHAPTER-IV

RESULTS AND DISCUSSION

The results of the study on the effect of different combination and composition of organic substrates on morphological, yield and yield related parameters have been presented in the following heads and probable discussion and interpretation have been made.

4.1. Time of emergence

Time of emergence was observed when potato sprouts came out from the soil level. Although one variety was used in this experiment but its emerging time was varied under different treatment and that variation was significant among the treatments at 1% level (Appedix II). The Sprout which emerged quickly (9.4 days) was grown in the combination of 25% soil+ 50% water hyacinth + 25% vermicompost (T_9). This quickest days was followed by T_7 (75% water hyacinth compost +25% vermicompost) (9.6 days), T_4 (50% water hyacinth compost +50% vermicompost) (9.6 days), T_1 (100% water hyacinth compost) (9.8 days), T_3 (50% soil+50% vermicompost) (10 days), T_8 (75% vermicompost+25% water hyacinth compost) (10 days) and T_{10} (50% soil +25% water hyacinth compost +25% vermicompost) (10.2 days) where T_7 and T_4 were statistically similar. The plantlet of T_3 and T_8 came out after 10 days and they were also statistically similar with T_1 and T_{10}. On the other hand, tuber which placed in the 100% soil (T_0) had taken longest time (18.8 days) to emerge and second highest time was 14.4 days observed in T_5 (75% soil + 25% water hyacinth compost) followed by T_6 (75% soil +25% vermicompost) and T_2 (50% soil+50% water hyacinth compost) (Table 1). T_9 might be provided favorable condition for quick emergence of the sprout because water hyacinth has good water holding and vermicompost improve the aeration of soil. Beside this, microbial activities also increased due to the use of vermicompost. Altogether overall condition enhanced emergence. In most of the cases higher percentage of water hyacinth acted as leading factor for quick emergence. Razzaque *et al.* (2000) explained that thick mulch helps to retain moisture in the soil and moisture helps to emergence of plant and in his experiment water hyacinth used as mulch in potato production. Experiment of Jalil *et al.* (2004) showed the opposite result with this study because he found that 80% plant emergence occurred at 17.93 days in water hyacinth medium. That result might be due to the varietal or environmental effect. Vermicompost helps in the germination of vegetable crops like okra, brinjal and chilli (Dhanalakshmi *et al.*, 2014) so it also helped in emergence of potato. But control treatment took maximum days it might be due to the compaction of soil or due to depth of planting. The chitted tubers were placed at 4 inch deep in container so watering was done over there repeatedly. As a result soil became compact and then plant forced to the compact soil to came out. However the study of Mc-Callum *et al.* (1998) also proved that application of compost improved seed germination.

4.2. Life span of potato plant

There was significant variation at 1% level (Appendix II) among the treatments in measuring life span of plant in respect of different combinations of organic substrates. The plant of T_8 (75% vermicompost+25% water hyacinth compost) lived for the least days (93.2 days). Where other less duration plants were observed in T_4 (50% water hyacinth compost +50% vermicompost) (96 days) and T_7 (75% water hyacinth compost +25% vermicompost) (99.2 days). Plant grown in T_3 (50% soil+50% vermicompost) continued their physiological process for the longest time (103.6 days) followed by T_0 (100% soil) (103.6 days), T_6 (75% soil +25% vermicompost) (103.6 days), T_5 (75% soil + 25% water hyacinth compost) (103.2

days), T_2 (50% soil+50% water hyacinth compost) (102.8 days), T_9 (25% soil +50% water hyacinth compost +25% vermicompost) (101.6 days), T_1 (100% water hyacinth compost) (101.2 days) and T_{10} (50% soil +25% water hyacinth compost +25% vermicompost) (101.2 days) (Table 1).

Table 1. Effect of different combinations of organic substrates on time of emergence and life span of plant

Treatments	Time of emergence (DAP)	Life span of potato plant (days)
T_0= 100% soil (control)	18.80a	103.60a
T_1=100% water hyacinth compost	9.80cd	101.20ab
T_2= 50% soil+50% water hyacinth compost	10.60c	102.80a
T_3= 50% soil+50% vermicompost	10.00cd	104.00a
T_4=50% water hyacinth compost +50% vermicompost	9.60d	96.00bc
T_5= 75% soil + 25% water hyacinth compost	14.40b	103.20a
T_6= 75% soil +25% vermicompost	14.00b	103.60a
T_7= 75% water hyacinth compost +25% vermicompost	9.60d	99.20ab
T_8= 75% vermicompost+25% water hyacinth compost	10.00cd	93.20c
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	9.40d	101.60a
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	10.20cd	101.20ab
Level of significance	**	**
CV (%)	4.33	2.83

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

In this case T_3, T_0, T_6, T_5 and T_2 were statistically similar and highly significant. Diamant variety completes their life cycle in 90-95 days (Hossain *et al.*, 2009) which was showed by the plant growing in T_8. The variation within the treatment might be occurred due to the microclimatic variation.

4.3. Plant height of potato

The plant height was significantly influenced by different treatments at different growth stages. The plant height was progressively increased from 27 DAP (days after planting) to 87 DAP where growth rate was very rapid from 27 DAP to 42 DAP. After 42 DAP plant continued their growth but slowly and plant height was increased very slowly from 72 DAP to 87 DAP. Data collection was started from 27 days after planting, so at 27 DAP plant height was varied significantly at 1% level (Appendix II) where highest plant height (16.16 cm) was found in T_7 (25% vermicompost+75% water hyacinth compost) treatment followed by T_1 (100% water hyacinth compost) (15.86 cm) treatment. But those two treatments T_7 and T_1 gave statistically similar results (16.16cm) and (15.86 cm) which were followed by T_9 (25% soil +50% water hyacinth compost +25% vermicompost) (15.14 cm), T_4 (50% water hyacinth compost +50% vermicompost) (14.49 cm), T_2 (50% soil+50% water hyacinth compost) (12.11 cm) and T_{10} (50% soil +25% water hyacinth compost +25% vermicompost) (11.99 cm). The plant attained in the smallest height (2.14cm) in the control treatment T_0 (100% soil) and it was preceded by T_6 (75% soil +25% vermicompost) (6.19 cm), T_5 (75% soil + 25% water hyacinth compost) (6.21 cm), T_3 (50% soil+50% vermicompost) (7.31 cm) and T_8 (75% vermicompost+25% water hyacinth compost) (9.65 cm) (Table 2). At 42 DAP plant height showed highly significant variation where plant height ranged from 6.77cm to 26.31cm and maximum height (26.31cm) was found in T_1 whose follower were T_4 (25.50 cm), T_7 (24.68 cm), T_9 (23.83 cm) and T_8 (22.66 cm). On the other hand, minimum height (6.77cm) was observed in T_0 treatment preceded by T_3 (11.33 cm), T_6 (13.59 cm), T_5 (15.27

cm), T_2 (20.48 cm) and T_{10} (20.48 cm). At that time although T_1 showed highest plant height but the growth rate was high in T_8 treatment. Plant height was ranged from 11.84cm to 28.59cm in T_0 and T_1 at 57 DAP where the treatment T_7 and T_4 presented second highest result. During 72 days after planting, T_0 and T_1 also gave the lowest (12.27cm) and the highest (29.60cm) result followed by others and T_4 and T_7 treatment were statistically similar with T_1. At the last date 87 DAP of data collection maximum (30.25cm) and minimum (13.93cm) height of plant was observed in T_0 and T_1 treatment where T_4 (29.34 cm) and T_7 (29.9 cm) treatment were also statistically similar result to T_1. Beside these T_8 (27.13 cm), T_9 (26.42 cm) and T_0 (13.93 cm), T_3 (14.28 cm) were statistically similar.

So in all the observation T_1 (100% water hyacinth compost) facilitated the plant to attain in highest height and T_0 (100% soil) leaded to the lowest height and in whole time of observation all the treatments maintained a consistency in increasing plant height. Water hyacinth conserves enough water and it contains nitrogen and high phosphorus and these mineral elements influence plant height (Zelalem *et al.*, 2009). Again vermicompost are reported to contain growth promoter such as auxin and cytokinin (Krishnamoorthy and Vajranabhaiah, 1986). So plant height of T_1 might be increased due to the presence of N and P and in T_4 and T_7 might be due to the activation of auxin and cytokinin or might be due to the combined effect of N, P and auxin and cytokinin. Vermincompost activates microbes that degrade unavailable P to available form and that favor the plant growth (Covarrubias-Ramírez *et al.*, 2005). After the activation of microorganism, rapid growth of plant took place. Jafari and Fonooni (2014) reported from the study that different amount of manure usage had statistically significant effects on plant height at 1% significant level (Appendix II).

Table 2. Effect of different combinations of organic substrates on plant height of potato

Treatments	Plant height (cm)				
	27 DAP	42 DAP	57 DAP	72 DAP	87 DAP
T_0= 100% soil (control)	2.14f	6.77f	11.84f	12.27gh	13.93f
T_1=100% water hyacinth compost	15.86a	26.31a	28.59a	29.60a	30.25a
T_2= 50% soil+50% water hyacinth compost	12.11c	20.48c	22.18d	23.18c	23.98c
T_3= 50% soil+50% vermicompost	7.31e	11.33e	12.93f	13.74g	14.28f
T_4=50% water hyacinth compost +50% vermicompost	14.49b	25.50ab	27.99ab	28.73a	29.34a
T_5= 75% soil + 25% water hyacinth compost	6.21e	15.27d	17.53e	18.44c	19.05de
T_6= 75% soil +25% vermicompost	6.15e	13.59de	16.52e	17.60ef	18.46e
T_7= 75% water hyacinth compost +25% vermicompost	16.16a	24.68ab	27.81ab	29.19a	29.9a
T_8= 75% vermicompost+25% water hyacinth compost	9.65d	22.66bc	26.09bc	26.85b	27.13b
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	15.14ab	23.83ab	25.39c	25.88b	26.42b
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	11.99c	20.48c	23.29d	26.34b	26.87b
Level of significance	**	**	**	**	**
CV (%)	7.06	9.19	5.25	6.60	7.31

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.4. Stem diameter plant^{-1}

The effect of different combinations of organic substrates on stem diameter of plant was statistically significant at $p \leq 0.01$ level (Appendix II). Data were collected four times of 15 days interval (27 DAP, 42 DAP, 57 DAP and 72 DAP). The lowest values (5.91mm, 5.95

mm and 6.49 mm) were found in the control treatment T_0 (100% soil) in all of the days except 27 DAP. At 27 DAP the lowest (5.12mm) stem diameter was observed in T_5 (75% soil + 25% water hyacinth compost) and the second lowest (5.30cm) value was found in T_0 and statistically the highest value (7.24mm and 6.8mm) were observed in T_1 (100% water hyacinth compost) and T_{10} (50% soil +25% water hyacinth compost +25% vermicompost) respectively and other treatments showed statistically second highest result. During 42 DAP statistically similar and highest values were marked in T_1 (5.91 mm), T_{10} (7.59 mm), T_8 (7.43 mm), T_9 (7.36 mm), T_4 (7.34 mm) and T_7 (7.28 mm) respectively and along with it T_2 (6.86 mm) and T_6 (6.83 mm) were also statistically similar (Table 3). But at 57 DAP and 72 DAP T_7 (75% water hyacinth compost +25% vermicompost) treatment provided maximum (9.32mm and 9.37 mm) result and remaining treatment showed medium value of diameter. In fact, a consistent result was found from T_7 (75% water hyacinth compost +25% vermicompost) from 27 DAP to 72 DAP where T_1 and T_{10} made best result at 27 DAP to 42 DAP but after that their result felled.

Although water hyacinth has good water holding capacity (Adesina *et al.*, 2011) and has mineral elements but with the time it became more dried and then water conservation and nutrient supply reduced and that affected on plant diameter. As only organic material was used in study and experiment was conducted on container so soil had no extra mineral element. As a result performance was bad in control. On the other hand, higher nitrogen content of vermicompost caused more meristems and more cell division to induce better plant growth and development (Tisdale and Nelson, 1975). For this reason 75% water hyacinth compost +25% vermicompost might be favored to increase stem diameter.

Table 3. Effect of different combinations of organic substrates on stem diameter plant^{-1}

Treatments	Stem diameter plant^{-1} (mm)			
	27 DAP	42 DAP	57DAP	72 DAP
T_0= 100% soil (control)	5.30bc	5.91c	5.95e	6.49de
T_1=100% water hyacinth compost	7.24a	7.59a	7.72bc	8.04bc
T_2= 50% soil+50% water hyacinth compost	6.39ab	6.86ab	6.99c	7.57c
T_3= 50% soil+50% vermicompost	6.34ab	6.65b	7.38c	7.68c
T_4=50% water hyacinth compost +50% vermicompost	6.25ab	7.34a	7.48c	8.11bc
T_5= 75% soil + 25% water hyacinth compost	5.12c	6.39b	6.96cd	7.69c
T_6= 75% soil +25% vermicompost	6.43ab	6.83ab	8.14b	8.28b
T_7= 75% water hyacinth compost +25% vermicompost	6.61ab	7.28a	9.32a	9.37a
T_8= 75% vermicompost+25% water hyacinth compost	5.90b	7.43a	7.60c	8.16bc
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	6.61ab	7.36a	7.96bc	8.11bc
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	6.8a	7.59a	7.87bc	8.10bc
Level of significance	**	**	**	**
CV (%)	10.01	6.5	6.31	5.6

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.5. Number of leaves plant^{-1}

As a growth parameter leaves number of plant was significantly affected by different combinations of organic substrates at $p \leq 0.01$ level (Appendix II). All the treatments exhibited significant difference compared to control. The leaves number of plant in the control treatment T_0 (100% soil) was worse (6.2, 7.4, 9.9, 10.39 and 11.5, respectively) among all other treatment at different day. Whereas the treatment T_4 (50% water hyacinth compost +50% vermicompost) produced more (12 and 17.7) number of leaves for up to first 42 DAP but after that leaf production rate reduced and finally leaves number decreased from 20.02 to 19.72 at 87 DAP. Meanwhile treatment T_7 (75% water hyacinth compost +25% vermicompost) produced medium number of leaves for first 42 DAP and then it showed maximum (20.62, 22.3 and 21.34, respectively) number of leaves from 57 DAP to 87 DAP but it also reduced its leaves number at 87 DAP. Plant of T_1 (100% water hyacinth compost) treatment also decreased leaves number at latter stage of growth. Beside this, T_8 (75% vermicompost+25% water hyacinth compost) treatment performed statistically higher result similar with T_4 at 42 DAP and leaves number of other plants in T_1, T_2, T3, T_5,T_9 and T_{10} were hackneyed in all the treatment (Table 4). In all the five growth stage the number of leaves was varied significantly at 1% level.

The reduction of leaves number at latter stage might be due to the shedding of leaves for aging but variation of leave number among different treatment would be for few causes. Water hyacinth and vermicompost both contain nitrogen (Appendix I) and nitrogen encourages the vegetative growth of plant and most specifically water hyacinth helps to vegetative growth (Adesina *et al.*, 2011). In T_7 (75% water hyacinth compost +25% vermicompost) treatment nutrient might be became more available for the plant due to the proper aeration for the presence of water hyacinth. But in more vermicompost containing treatment, medium became concentrated and then nutrient might not be available for plant and in only water hyacinth containing medium nutrient were not sufficient for providing more number of leaves. Islam (2007) also found significant effect of organic matter on number of potato leaf. Alam *et al.* (2007) found that leaf number was increased rapidly up to

60 days and then gradually increased. Naher (1999) showed that the maximum number of leaf were obtained at 90 DAP by organic or inorganic and their combinations.

Table 4. Effect of different combinations of organic substrates on leaves number plant^{-1}

Treatments	Leaves number plant^{-1}				
	27 DAP	42 DAP	57 DAP	72 DAP	87 DAP
T_0= 100% soil (control)	6.20e	7.40ef	9.90h	10.39g	11.50g
T_1=100% water hyacinth compost	10.90ab	13.99bc	15.10d	17.30d	13.90e
T_2= 50% soil+50% water hyacinth compost	9.52bc	12.65c	13.71e	16.70d	20.40b
T_3= 50% soil+50% vermicompost	9.20c	11.90cd	11.90fg	12.10f	12.61f
T_4=50% water hyacinth compost +50% vermicompost	12.00a	17.70a	19.25b	20.02b	19.72bc
T_5= 75% soil + 25% water hyacinth compost	7.91cd	10.38d	11.40g	12.30ef	13.81e
T_6= 75% soil +25% vermicompost	8.20cd	11.20d	12.42f	12.90e	14.30e
T_7= 75% water hyacinth compost +25% vermicompost	10.30b	14.29bc	20.62a	22.30a	21.34a
T_8= 75% vermicompost+25% water hyacinth compost	9.00c	16.80a	18.60c	18.90c	19.41c
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	10.40b	14.33bc	14.61d	17.40d	15.81d
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	9.20c	12.80c	13.70e	18.40c	19.70bc
Level of significance	**	**	**	**	**
CV (%)	8.63	9.48	2.49	2.74	2.46

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.6. Length of leaf

According to the result from table it is revealed that length of leaf was deviated significantly among the treatments at 1% level (Appendix II) in all the time of data collection.

Table 5. Effect of different combinations of organic substrates on leaves length

Treatments	Leaf length (cm)			
	27 DAP	42 DAP	57 DAP	72 DAP
T_0= 100% soil (control)	3.05g	3.64e	5.62f	8.17hi
T_1=100% water hyacinth compost	9.74ab	14.84a	16.01a	17.04a
T_2= 50% soil+50% water hyacinth compost	9.11b	13.95ab	15.15ab	16.26b
T_3= 50% soil+50% vermicompost	6.48d	10.27cd	11.58de	12.72de
T_4=50% water hyacinth compost +50% vermicompost	8.23bc	13.30b	14.38b	15.06bc
T_5= 75% soil + 25% water hyacinth compost	4.81ef	9.49d	10.77e	12.66de
T_6= 75% soil +25% vermicompost	4.99ef	10.93c	12.72cd	14.13cd
T_7= 75% water hyacinth compost +25% vermicompost	8.29bc	13.84ab	14.91ab	15.99b
T_8= 75% vermicompost+25% water hyacinth compost	6.33de	11.48c	14.07bc	15.14bc
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	10.48a	15.22a	16.27a	17.50a
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	9.43ab	14.52ab	15.61ab	16.32ab
Level of significance	**	**	**	**
CV (%)	9.32	6.23	6.43	4.91

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

At 27 DAP, T_9 (25% soil +50% water hyacinth compost +25% vermicompost) ranked as top for production of highest length leaf (10.48 cm) which was followed by T_1(100% water hyacinth compost) (9.74 cm), T_{10} (50% soil +25% water hyacinth compost +25% vermicompost) (9.45 cm), T_2 (50% soil+50% water hyacinth compost) (9.11 cm), T_7 (75% water hyacinth compost +25% vermicompost) (8.29 cm) and T_4 (50% water hyacinth compost +50% vermicompost) (8.23 cm) where T_1 and T_{10} were ranked as second highest in giving leaf length of potato and they were statistically similar. The T_0 (100% soil) treatment ranked as lowest (3.05 cm) proceeded by T_5 (75% soil + 25% water hyacinth compost) (4.81 cm), T_6 (75% soil +25% vermicompost) (4.99 cm), T_8 (75% vermicompost+25% water hyacinth compost) (6.33 cm) and T_3 (50% soil+50% vermicompost) (6.48 cm) (Table 5). Leaf length was always less (3.64cn, 5.62cm and 8.1cm) in control treatment than other while the plant of T_9 treatment always maintained maximum length of leaves (15.22cm, 16.27cm and 17.5cm respectively) up to 72 DAP. Meanwhile T_1 treatment also showed statistically highest result from 42 DAP to 72 DAP beside this, it was statistically similar to T_9. Although T_7 produced maximum number of leaves but T_9 increased the length of leaf. In this case combination of soil, water hyacinth and vermicompost in that proportion might be activated the cytokinin of plant which enhanced the enlargement of cell.

4.7. Leaflet number leaf^{-1}

Plant growth and development as well as tuber formation are depends on photosynthesis and major part of photosynthesis depends on leaves along with leaflet. So leaflet number is important for plant and which was significantly ($p \leq 0.01$) influenced by different combinations of organic substrates at different growth stage (Appendix III). Data was collected from 27 DAP, 42 DAP, 57 DAP and 72 DAP and except T_0 (100% soil) all the treatment performed well.

Table 6. Effect of different combinations of organic substrates on leaflet number $leaf^{-1}$

Treatments	Leaflet number $leaf^{-1}$			
	27 DAP	42 DAP	57 DAP	72 DAP
T_0= 100% soil (control)	2.06g	2.47g	3.49fg	4.27c
T_1=100% water hyacinth compost	4.05cd	5.80a	6.02a	6.37a
T_2= 50% soil+50% water hyacinth compost	4.05cd	5.13b	5.80a	6.21a
T_3= 50% soil+50% vermicompost	3.19e	4.30cd	4.67cd	5.07b
T_4=50% water hyacinth compost +50% vermicompost	4.17bc	5.30ab	5.50b	5.74a
T_5= 75% soil + 25% water hyacinth compost	2.39f	3.54ef	4.11e	5.07b
T_6= 75% soil +25% vermicompost	2.55f	3.74de	4.30de	4.80bc
T_7= 75% water hyacinth compost +25% vermicompost	4.56a	5.63a	5.83a	5.97a
T_8= 75% vermicompost+25% water hyacinth compost	3.81d	4.84bc	5.16bc	5.87a
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	4.41ab	5.56a	5.60ab	6.10a
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	4.09cd	5.46ab	5.73ab	5.97a
Level of significance	**	**	**	**
CV (%)	4.95	6.83	5.21	6.00

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

The plant of T_7 (75% water hyacinth compost +25% vermicompost) treatment produced maximum (4.56) number of leaflet at 27DAP and then produced statistically highest result at 72 DAP. At 27 DAP, T_1 (100% water hyacinth compost) (2.06), T_2 (50% soil+50% water hyacinth compost) (4.05) and T_9 (25% soil +50% water hyacinth compost +25% vermicompost) (4.41) exhibited third and second highest number of leaflets but from 42 DAP to 72 DAP the treatment T_1 and T_9 produced maximum number of leaflet and T_2 produced statistically highest number of leaflets from 57 DAP to 72 DAP. The treatment T_5 (2.39), T_6 (2.55), T_3 (3.19), T_8 (3.81) and T_4 (4.17) were not performed well at 27 DAP but after that its performance progressively increased. At 72 DAP the treatment T_1 (6.37), T_2 (6.21), T_9 (6.1), T_7 (5.97), T_{10} (5.97), T_8 (5.87) and T_4 (5.74) were produced statistically higher number of leaves respectively followed by T_3 (5.07), T_5 (5.07) and T_6 (4.8) where T_0 gave the lowest number of leaflet (2.06, 2.47, 3.49 and 4.27 respectively) at 27 DAP, 42 DAP, 57 DAP and 72 DAP (Table 6). Organic substance might improved the physical properties of soil, increased the porosity and moisture conserving capacity which would help to make mineral elements available for the plant that facilitated foliage production.

4. 8. Leaflet length and breadth

Leaflet length and breadth were measured from 28 DAP to 73 DAP and both of the growth parameters were varied significantly ($p \leq 0.01$) among the treatments at all growth stages (Appendix III). Length and breadth of leaflet were always significantly smaller in control treatment (1.85/1.31; 2.17/2.03; 2.7/2.36 and 3.66/2.58 respectively) at 28, 43, 58 and 73 DAP. The leaflet length and breadth of the plant of T_{10} (50% soil +25% water hyacinth compost +25% vermicompost) (Table 7) were statistically more at all the stage of growth and the treatment T_9 (25% soil +50% water hyacinth compost +25% vermicompost) provided highest result from 28 DAP to 43 DAP and then it showed statistically similar result to T_{10} and other treatments showed medium result.

Table 7. Effect of different combinations of organic substrates on leaflet length and breadth

Treatments	Leaflet length and breadth (cm)							
	28 DAP		43 DAP		58 DAP		73 DAP	
T_0= 100% soil (control)	1.85e	1.31gh	2.17g	2.03f	2.76f	2.36d	3.66fg	2.58d
T_1=100% water hyacinth compost	3.73a	2.47b	4.86ab	3.30ab	5.38ab	3.56b	5.71ab	3.66bc
T_2= 50% soil+50% water hyacinth compost	3.72a	2.53b	4.50bc	3.23ab	4.99bc	3.56b	5.53b	3.81b
T_3= 50% soil+50% vermicompost	2.84c	2.24c	3.85ef	2.70cd	4.46de	3.13c	4.83cd	3.30c
T_4=50% water hyacinth compost +50% vermicompost	3.09c	2.65ab	4.41cd	3.21ab	5.12b	3.69ab	5.56b	3.82b
T_5= 75% soil + 25% water hyacinth compost	2.33d	2.00de	3.53f	2.72cd	4.11e	2.91c	4.80cd	3.31c
T_6= 75% soil +25% vermicompost	2.32d	2.08d	4.08de	3.09b	4.73cd	3.51b	5.21bc	3.70bc
T_7= 75% water hyacinth compost +25% vermicompost	3.39b	2.26c	4.54bc	3.30ab	5.12b	3.55b	5.52b	3.68bc
T_8= 75% vermicompost+25% water hyacinth compost	2.87c	2.43b	4.02e	2.30bc	5.34ab	3.56b	5.63ab	3.75b
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	3.99a	2.77a	5.13a	3.48a	5.54a	3.65ab	5.98a	3.84b
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	3.81a	2.69a	5.07a	3.43a	5.59a	3.98a	6.02a	4.33a
Level of significance	**	**	**	**	**	**	**	**
CV%	5.52	5.46	4.95	5.54	4.34	5.68	4.52	5.92

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

The leaf length of the treatment T_9 was also the highest, so it can be mentioned that the factor which caused higher leaf length might be responsible for higher leaflet length and breadth.

4.9. Number of main stems plant^{-1}

The different combinations of organic substrates had significant ($p \leq 0.01$) influence on the production of number of main stem per plant compared to no organic materials treatment (Appendix III). Among the eleven treatments T_8 (75% vermicompost+25% water hyacinth compost) was ranked as top (5.3) and disciples of this treatment were T_7 (75% water hyacinth compost +25% vermicompost) (4), T_1 (100% water hyacinth compost) (3.27), T_5 (75% soil + 25% water hyacinth compost) (3.8), T_9 (25% soil +50% water hyacinth compost +25% vermicompost) (3.4), T_{10} (50% soil +25% water hyacinth compost +25% vermicompost) (3.3) and T_4 (50% water hyacinth compost +50% vermicompost) (3.2) and all of these seven treatments were statistically similar. On the other hand with the control treatment T_6 (75% soil +25% vermicompost) also presented the lowest (2.2) result followed by T_2 (50% soil+50% water hyacinth compost) (2.4) and T_3 (50% soil+50% vermicompost) (2.4) (Table 8). Vermicompost significantly improve soil quality and increase availability of food for crops and it contains humic acids which are necessary for plant health to synthesis phenolic compounds such as anthocyanins and flavonoids. These phenolic compounds improve plant quality (Theunissen *et al.*, 2010). Soil microbes become active in the present of vermicompost that influence the plant to produce plant growth-influencing substances (Arancon *et al.*, 2005) and such plant growth hormones might be influenced to produce higher main stem. With this water hyacinth improved the nutrient status of the medium that helped to increase main stem number (Gunnarssen and Petersen, 2006). Rahman and Akanda (2009) found significant variation in number of main stem under different treatments but Jalil *et al.* (2004) did not find significant variation in number of main stem when water hyacinth and rice straw used as mulch. But soil containing medium did not provide favorable condition for plant growth as experiment was conducted in container so plants were not capable to use mineral elements from underground and then they had to use confined nutrient within the soil of container. As a result less vegetative growth took place. But some study stated that stem number is not influenced much by mineral nutrients rather it is influenced by other factors such as storage condition of tubers, number of viable sprouts at planting, sprout damage at the time of planting and growing conditions (Allen, 1978), physiological age of the seed tuber (Iritani, 1968), variety (Lynch and Tai, 1989) and tuber size (Harris, 1978). But Alam *et al.* (2007) also found that number of main stem per hill was significantly influenced by application of different treatments where highest number of main stem per hill produced by the application of vermicompost and the plant having no fertilizer produced the minimum number of main stem per hill. Naher (1999) stated that the maximum number of main stem (3.65) per hill was obtained from organic fertilizer management practices (organic, organic+ inorganic). So this experiment showed similarity with Naher (1999) and Alam *et al.* (2007).

4.10. Fresh weight of shoot plant^{-1}

At the day of harvesting, each plant was weighed for getting fresh weight and a significant difference at 1 % level was found due to the effect of organic substrates in respect of fresh weight of shoot per plant at harvest (Appendix III). The maximum fresh weight of shoot (27.34g) was observed from T_7 (75% water hyacinth compost +25% vermicompost) followered by were T_1 (100% water hyacinth compost) (2.0g), T_2 (50% soil+50% water hyacinth compost) (21.4g), T_4 (50% water hyacinth compost +50% vermicompost) (17.03g),

T_5 (75% soil + 25% water hyacinth compost) (16.72g), T_9 (25% soil +50% water hyacinth compost +25% vermicompost) (15.6g), T_{10} (50% soil +25% water hyacinth compost +25% vermicompost) (15g) and T_8 (75% vermicompost+25% water hyacinth compost) (14.53g) and T_{10} and T_8 were statistically similar. In case of control T_0 (100% soil) treatment fresh weight of shoot was extremely lower (2g) and T_6 (75% soil +25% vermicompost) treatment also gave lower weight of shoot (8.23g) followed by T_3 (50% soil+50% vermicompost) (17.03g) (Table 8). Mainly fresh weight of shoot depends on leaves number, main stem number, leaflet number and overall physical condition of plant (Islam, 2007). Plant of control treatment and other worse performing treatment had lowest number of leaves and main stems, so finally their shoot weight reduced. Beside, T_7 (75% water hyacinth compost +25% vermicompost) always performed well in all growth parameters. Although T_8 (75% vermicompost+25% water hyacinth compost) produced higher main stem and good number of leaves but its fresh weight was not higher and this result might be due to the reduction of watery substances. Because during the growth period, the plant of high vermicompost medium produced more succulent and thick leaves and with the physiological maturity leaves became thin. So it could be affected the fresh weight of shoot. Islam (2007), Jalil *et al.* (2004) and Amanullah *et al.* (2010) expressed the significant variation in fresh weight of plant. The study of Alam *et al.*, (2007) exhibited that the fresh weight of shoot was markedly varied due to the application of organic fertilizer and maximum result was observed from vermicompost treated plants. But Naher (1999) explained that the highest the fresh weight of shoot was produced by the plant of inorganic fertilizer.

Table 8. Mean value of number of main stem plant^{-1} and fresh weight of shoot plant^{-1} in different combinations of organic substrates

Treatments	Number of main stem plant^{-1}	Fresh weight of shoot plant^{-1} (g)
T_0= 100% soil (control)	2.20c	2.00i
T_1=100% water hyacinth compost	3.27b	24.60b
T_2= 50% soil+50% water hyacinth compost	2.40c	21.40c
T_3= 50% soil+50% vermicompost	2.40c	12.40g
T_4=50% water hyacinth compost +50% vermicompost	3.2b	17.03d
T_5= 75% soil + 25% water hyacinth compost	3.80b	16.72de
T_6= 75% soil +25% vermicompost	2.20c	8.23h
T_7= 75% water hyacinth compost +25% vermicompost	4.00b	27.34a
T_8= 75% vermicompost+25% water hyacinth compost	5.30a	14.53f
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	3.40b	15.60ef
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	3.30b	15.00f
Level of significance	**	**
CV (%)	13.40	4.32

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4. 11. Number of tuber plant^{-1}

Tuber production is the ultimate goal of plant production. The results showed that treatments of organic matters were significant at 1% level on number of tubers (Appendix IV). Most tubers formed in higher vermicompost containing medium. The lowest (6) number of tubers was obtained in the treatments T_6 (75% soil +25% vermicompost) and it had significant difference with most of treatments. This result was followed by T_0 (100% soil) (6.4), T_3 (50% soil+50% vermicompost) (6.8), T_2 (50% soil+50% water hyacinth compost) (7.8) and T_{10}

(50% soil +25% water hyacinth compost +25% vermicompost) (9.8) and T_0 and T_6 were statistically similar. The highest number of tubers (24.21) was produced from the plant grown in T_8 (75% vermicompost+25% water hyacinth compost). The second highest number of tuber (16.8) was grown in T_7 (75% water hyacinth compost +25% vermicompost) followed by T_4 (50% water hyacinth compost +50% vermicompost) (16.01), T_1(100% water hyacinth compost) (14.4) and T_9 (25% soil +50% water hyacinth compost +25% vermicompost) (11.2) (Table 9). Low soil N is known to be a factor limiting potato production although adequate water is available (Harris, 1992). In case of T_6 treatment soil had less nitrogen which hindered the tuber formation. Meanwhile the best performance of T_8 might be for few reasons. Mineral element Zinc leads to produce more number of tuber but small size (Taheri *et al.*, 2011) and vermicompost contains 100 ppm Zn and water hyacinth contains 73 ppm (Appendix I), so high Zn content might be helped to produce more tuber. Besides this, tuber number increase in response to nitrogen. Nitrogen activates the gibberellins in the potato plant and gibberellins biosynthesis regulates the stolon number and growth (Kumar and Wareing, 1972) and on the other side water hyacinth and vermicompost both contain nitrogen. Kanzikwera *et al.* (2001) also revealed that nitrogen availability before tuber initiation increase tuber number. Nitrogen leaching may affect the tuber formation but as plant was grown in container no significant nitrogen leaching occurred. Panique *et al.* (1997) reported a significant tuber yield increase occurred due to the use of K. It also found from study that water hyacinth retained moisture in the soil for longer period, which ultimately maximized the tuber number per plant and increased tuber yield (Razzaque and Ali, 2009). Study of Tabatabai *et al.* (2014) explained that the nutrient of biological fertilizer increase the number of tuber by creating suitable condition for plant. Alam *et al.* (2007)

stated that plant of only soil medium produced minimum number of tuber while the plant of vermicompost medium gave maximum number of tuber.

4.12. Tuber length and breadth

According to variance analysis results of different combinations of organic substrates affected tubers size significantly at $p \leq 0.01$ level (Appendix IV). Length and breadth of the tuber were varied among the different treatments but breadth showed more variation comparing to the length. The tuber produced in T_7 (75% water hyacinth compost +25% vermicompost) had maximum length (70.80 mm) and breadth (48.90 mm) while T_4 (50% water hyacinth compost +50% vermicompost) (67.2 mm) and T_1 (100% water hyacinth compost) (67.14 mm) produced statistically maximum length of tuber and it was followed by T_2 (50% soil+50% water hyacinth compost) (63.7 mm), T_{10} (50% soil +25% water hyacinth compost +25% vermicompost) (63.20 mm), T_3 (50% soil+50% vermicompost) (62.80 mm) and T_9 (25% soil +50% water hyacinth compost +25% vermicompost) (61.30 mm) and all of these treatments were statistically similar and presented second highest result and the next ranked treatment were T_6 (75% soil+25% vermicompost) (58.8 mm), T_8 (75% vermicompost+25% water hyacinth compost) (56.20 mm) and T_5 (75% soil + 25% water hyacinth compost) (55.45 mm) respectively (Table 9). At the same time control treatment provided the minimum length (52.28mm) and breadth (33.02mm) of tuber and the next lowest result of breadth (41.50 mm) was exhibited by T_5 treatment. The highest (48.90mm) value of breadth was followed by T_9 (46.67 mm), T_2 (46.03 mm), T_1 (45.32 mm), T_{10} (45.25 mm), T_4 (42.92 mm), T_6 (43.22 mm) and T_5 (41.50 mm) respectively and here T_9 and T_2 and again $T_1$and T_{10} gave statistically similar result. The lowest value of the breadth was followed by T_3 (38.11 mm) and T_8 (39.76 mm) treatment.

Water hyacinth gave excellent aeration, porosity, drainage and moisture holding capacity and contains higher level of mineral element in available form and vermicompost and water hyacinth both improve the physical and chemical properties of soil. For porosity and good aeration better root development as well as stolon elongation took place and finally expansion of tuber might be become easier. On the other hand, compact soil impeded the enlargement of tuber but addition of compost improved soil structure and make well ventilated and that reduced the soil resistance (Tu *et al.*, 2006 and Arancon *et al.*, 2005). Microorganism's activity is low in poor or no organic matter soil. But when organic materials mixed with soil then it increase microorganism and that microbes make unavailable nutrients in available form and as a result nutrient contribute to the tuber development (Zublena *et al.*, 1991).

4.13. Weight of tuber container^{-1}

A fluctuation of tuber weight increment was noticed among different combinations of organic substrates treatments and that fluctuation of tuber weight was significant at 1% (Appendix IV). Statistically highest weight of tuber per container (644.8g) was obtained from T_7 (75% water hyacinth compost +25% vermicompost) treatment. The tuber weight 574.4g, 540.4g, 518g, 492g, 450.4g and 443.6g were weighed from the treatment T_9 (25% soil +50% water hyacinth compost +25% vermicompost), T_1 (100% water hyacinth compost), T_{10} (50% soil +25% water hyacinth compost +25% vermicompost), T_2 (50% soil+50% water hyacinth compost), T_4 (50% water hyacinth compost +50% vermicompost) and T_8 (75% vermicompost+25% water hyacinth compost), respectively. The weight of tuber from the control treatment T_0 (100% soil) was below the mark (192.8g/container) and tuber weight from T_3 (50% soil+50% vermicompost) was ranked below the result of T_0 in regard to the lowest value trend and it was preceded by T_5 (75% soil + 25% water hyacinth compost) (395.6g) and T_6 (75% soil +25% vermicompost) (295.2g). While T_0 and T_3 were statistically similar (Table 9). Although the treatment T_8 produced the highest number of tuber, it did not give maximum weight of tuber. Because T_8 treatment produced smaller tuber and it was more succulent at immature stage and with the maturity it lose water. Mainly nitrogen and phosphorus flourish total tuber yield because they increase total leaf area and leaf number that increase solar radiation interception. Then more photoassimilate produced in the leaf and that assimilated to the tubers (Millard and Marshall, 1986) and Kotsyuk (1995) agreed with this too. So, the assimilation of more photosynthetes might be causes of maximum weight of tuber. On the other hand tuber weight also depends on vegetative structure of plant and vegetative growth of the plant of control treatment was very poor and for this reason tuber might not be more weighed. Only soil or maximum soil containing medium became hard which had less water conservation ability. For this reason, it did not allow the easy movement of nutrient to the plant. Again as study was done in container, so, it was not always possible to make the soil friable and then it reduced both number and weight of tuber. The study of Islam, (2007) showed that weight of tuber was significantly higher in organic medium than control and it was similar with the present study. Ansari (2008) showed that yield of potato was increased in vermicompost treating plot. Baniuniene and Zekaite (2008) stated that organic matter increase the yield of potato in 38 to 82%. Razzaque and Ali (2009) also observed that potato grown in water hyacinth medium gave higher weight as well as maximum yield of tuber.

Table 9. Effect of different combinations of organic substrates on yield performance of potato

Treatment	Number of tuber plant^{-1}	Tuber length and breadth		Weight of tuber container^{-1} (g)
		Length (mm)	Breadth (mm)	
T_0= 100% soil	6.40g	52.28c	33.02ef	192.80j
T_1=100% water hyacinth compost	14.40c	67.14a	45.32b	540.40c
T_2= 50% soil+50% water hyacinth compost	7.80f	63.70ab	46.03ab	492.40e
T_3= 50% soil+50% vermicompost	6.80fg	62.80ab	38.11d	265.20i
T_4=50% water hyacinth compost +50% vermicompost	16.01b	67.20a	42.92bc	450.40f
T_5= 75% soil + 25% water hyacinth compost	10.00e	55.45bc	41.50c	395.60g
T_6= 75% soil +25% vermicompost	6.00g	58.86b	43.22bc	295.20h
T_7= 75% water hyacinth compost +25% vermicompost	16.80b	70.80a	48.90a	644.80a
T_8= 75% vermicompost+25% water hyacinth compost	24.21a	56.20bc	39.76cd	443.60f
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	11.20d	61.30ab	46.67ab	574.40b
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	9.80e	63.20ab	45.25b	518.00d
Level of significance	**	**	**	**
CV (%)	5.89	8.34	12.42	2.10

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

4.14. Economic analysis

Economic analysis was done with a view to observing the comparative cost and benefit under different combinations of organic substrates treatments. For this reason cost of seed, vermicompost, bags and labor were recorded against each treatment where cost of soil and water hyacinth was not considered, which were then enumerated in to cost per container.

The cost of production ranged from 8.76Tk to 83.76Tk per container and highest cost of production was required for the treatment T_8 (75% vermicompost+25% water hyacinth compost). The treatment T_{10} (50% soil +25% water hyacinth compost +25% vermicompost), T_9 (25% soil +50% water hyacinth compost +25% vermicompost), T_7 (75% water hyacinth compost +25% vermicompost) and T_6 (75% soil +25% vermicompost) needed same amount of cost (33.76 Tk per contaimer) while the lowest cost of production was needed by T_0 (100% soil) preceded by T_2 (50% soil+50% water hyacinth compost), T_3 (50% soil+50% vermicompost) and T_5 (75% soil + 25% water hyacinth compost). Gross return from potato plant was ranged from 4.63Tk to 15.48Tk per container where maximum gross return was found in T_7 preceded by T_9, T_1, T_{10}, T_2, T_4 and T_8 and minimum was found from T_0 followed by T_3, T_6 and T_5. In case of net return scenario was changed because T_1 (100% water hyacinth compost) treatment gave the maximum net income (4.21Tk per container) followed by T_2 and T_5. While T_8 treatment gave the lowest net income (-73.11Tk). So the highest (1.48) benefit cost ratio was found from 100% water hyacinth treatment (T_1) followed by T_2 (1.35) and T_5 (1.08) while lowest (0.11) benefit cost ratio was observed in T_3 (50% soil+50% vermicompost) (Table 10). Except three treatments (T_1, T_2 and T_5) all the benefit cost ratio gave losing results. The treatment T_7 gave the highest gross return but due to the high input cost its production was not beneficial and most specifically for vermicompost. Although vermicompost gave good performance in production but its price was too high and that affect the total outcome. On the other hand, potatoes grow well in field condition for mass production. But present study was conducted on container for small scale production where the potato plant did not get enough space for tuber growth. As a result production was decreased and on the other hand, cost of production increased.

Table 10. Cost and return analysis of potato production

Treatment	Yield container^{-1} (g)	Gross return (Tk container^{-1})	Cost of production (Tk container^{-1})	Net return (Tk container^{-1})	Benefit cost ratio (Tk container^{-1})
T_0= 100% soil	192.80j	4.63j	8.76	-4.13d	0.53c
T_1=100% water hyacinth compost	540.40c	12.97c	8.76	4.21a	1.48a
T_2= 50% soil+50% water hyacinth compost	492.40e	11.82e	8.76	3.06b	1.35a
T_3= 50% soil+50% vermicompost	265.20i	6.37i	58.76	-52.40j	0.11e
T_4=50% water hyacinth compost +50% vermicompost	450.40f	10.81f	58.76	-47.95i	0.18e
T_5= 75% soil + 25% water hyacinth compost	395.60g	9.49g	8.76	0.73c	1.08b
T_6= 75% soil +25% vermicompost	295.20h	7.09h	33.76	-26.68h	0.21de
T_7= 75% water hyacinth compost +25% vermicompost	644.80a	15.48a	33.76	-18.28e	0.46c
T_8= 75% vermicompost+25% water hyacinth compost	443.60f	10.65f	83.76	-73.11k	0.13e
T_9= 25% soil +50% water hyacinth compost +25% vermicompost	574.40b	13.79b	33.76	-19.97f	0.41c
T_{10}= 50% soil +25% water hyacinth compost +25% vermicompost	518.00d	12.43d	33.76	-21.33g	0.37cd
Level of significance	**	**		**	**
CV (%)	2.10	2.10		-0.95	2.69

**= Significant at 1% level. Means followed by common letter(s) in a column do not differ significantly by DMRT.

Cost of Vermicompost @ Tk. 10/kg

Cost of Bag @ Tk. 2/piece

Sale of potato @ Tk. 24 /kg

Gross return = Total yield (g/container) ×Tk. 24/1000

Benefit cost ratio (BCR) = Gross return ÷ Total cost of production

Net return= Gross return - total cost of production

So finally it can be found that 100% water hyacinth compost (T_1), 50% soil+50% water hyacinth compost (T_2) and 75% soil + 25% water hyacinth compost (T_5) are beneficial for small scale production of potato in container but vermicompost containing medium are not beneficial for small scale production of potato in container.

CHAPTER-V

SUMMARY AND CONCLUSIONS

The experiment was conducted in the Addhapk Purnendu Gein Field Laboratory of Agrotechnology Discipline of Khulna University, Khulna from December 2013 to April 2014 with a view to evaluate the effect of different combination of organic materials on plant growth and yield of potato. A single potato variety (Diamant) was used for the study and eleven different combinations of growth media were taken as: T_0 (100% soil), T_1 (100% water hyacinth compost), T_2 (50% soil with 50% water hyacinth compost), T_3 (50% soil with 50% vermicompost), T_4 (50% water hyacinth compost and 50% vermicompost), T_5 (75% soil with 25% water hyacinth compost), T_6 (75% soil and 25% vermicompost), T_7 (75% water hyacinth compost and 25% vermicompost), T_8 (75% vermicompost and 25% water hyacinth compost), T_9 (25% soil with 50% water hyacinth compost and 25% vermicompost) and T_{10} (50% soil with 25% water hyacinth compost and 25% vermicompost). The experiment was conducted in container. The experiment was laid out Completely Randomized Design method with five replications. Tuber was made ready for planting after chitting process and at 14 December tuber was planted in the container. Several parameters (Time of emergence, duration of crops, plant height, stem diameter $plant^{-1}$, number of leaves $plant^{-1}$, leaf length, leaflet number, leaflet length and breadth, number of main stem $plant^{-1}$, fresh weight of plant, number of tuber, tuber length and breadth and weight of tuber) were selected for collecting data and data collection started from 27 DAP and continued for 87 DAP. Collected data were analyzed following the ANOVA-1 technique of CRD and mean values were adjudged using DMRT test at 1% level and all those processes were carried out using computer program MSTAT-C.

Results of the study through the analysis revealed that both growth and yield parameters varied significantly at 1% level among the treatments. The treatment T_9 (25% soil+ 50% water hyacinth + 25% vermicompost) gave quickest (9.4 days) emergence where statistically earliness (9.4, 9.6 and 9.6 days) of emergence was shown by three treatment T_9, T_7 and T_4, respectively. Plant grown in T_3 (50% soil+50% vermicompost) continued their physiological process for the longest time (103.6 days) and the plant of T_8 (75% vermicompost+25% water hyacinth compost) lived for the least day (93.2 days) and life duration of T_4 (50% water hyacinth compost +50% vermicompost) and T_7 (75% water hyacinth compost +25% vermicompost) were 96days and 99.2 days. In measuring plant height consistently higher results were observed in T_1 and T_7 and later stage of growth statistically maximum height of the plant was 30.25cm, 29.9cm and 29.34cm by T_1, T_7 and T_4, respectively. The maximum leaf number was observed in T_4 (12 and 17.7) for first few days and T_7 (20.62, 22.3 and 21.34) showed higher number of leaves for remaining days and this variation might be occurred for fluctuation of nutrient status in the container. The highest (10.48cm, 15.22cm, 16.27cm, 17.5cm) number of length was vigilance in T_9 treatment at four date of data collection and sometimes statistically higher result was found in T_1 and T_{10}. The maximum number of leaflet was found in T_7 treatment but maximum leaflet length and breadth were observed in T_9 and T_{10}. The value 5.3 was the highest number of main stem produced by T_8 and T_7 gave the second highest number of main stem (4) but in case of shoot fresh weight T_7 was marked as top (27.34g) value giving treatment. Tuber number of the treatment T_8 (75% vermicompost+25% water hyacinth compost) was ranked first (24.21) and immediate follower was T_7 which produced 16.8 tuber. Although T_8 gave maximum number of tuber, T_7 gave maximum length (70.80mm) and breadth (48.90mm) and also maximum weight (644.8g per container) of tuber. The treatment T_9 (25% soil +50% water hyacinth compost +25% vermicompost) also produced higher weight of tuber (574.4g per container) followed by T_1(100% water hyacinth compost) (540.4g).

On the other hand, the plant grown in 100% soil (T_0) performed very worse and always gave lowest value for all the parameters except number of tuber where it ranked the second lowest. Within the combination, poor performance was exhibited by T_6 (75% soil and 25% vermicompost) followed by T_3 (50% soil+50% vermicompost).

In benefit cost analysis, cost of production ranges from 8.76Tk to 83.76Tk per container and T_8 (75% vermicompost+25% water hyacinth compost) treatment required maximum costs (83.76Tk per container) comparing to others. Maximum (15.48Tk per container) gross production came out from T_7 and the lowest (4.63Tk) value from T_0. But net return and benefit cost ratio were maximum in T_1 (100% water hyacinth compost) followed by T_2 (50% soil with 50% water hyacinth compost) and T_5 (75% soil with 25% water hyacinth compost) while the lowest value of net production and benefit cost ratio were observed in T_8 (75% vermicompost and 25% water hyacinth compost). De facto vermicompost containing gave losing result in benefit cost ratio but 100% water hyacinth gave economically viable results.

From the study it can be concluded that organic materials have positive influence on potato plants growth, yield and yield contributing characters. Although sometimes T_1, T_9, T_{10}, T_4 and T_8 performed best, yet among all the parameters and all the treatment overall performance of T_7 (75% water hyacinth compost +25% vermicompost) was good and consistent. But in economic analysis maximum benefit cost ratio was obtained from T_1 (100% water hyacinth). So, finally it can be said that for container production T_1 (100% water hyacinth) is beneficial and it can meet up self sufficiency but T_7 (75% water hyacinth compost +25%

vermicompost) or other vemicompost containing medium are not economically viable for small scale production of potato in container.

Because the higher price of vermicompost, it affected the returns. But if farmer produced the vermicompost by himself then it will be beneficial for production. On the other hand, used growth media can be further utilized for other crop production when BCR will be higher. But it was not practiced in this current study. This study was small scale production and first trial in this region. So, it is suggested to run this study for more precision.

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APPENDICES

Appendix I. Composition of water hyacinth and vermicompost

Name of the mineral elements	Composition of water hyacinth	Composition of vermicompost
	Amount of nutrient (ppm)	Amount of nutrient (ppm)
Nitrogen	630	19000
Phosphorus	2282.13	20000
Potassium	7800	8000
Sulpher	4025	
Zinc	73	100
Boron	142.5	142.5
Calcium	1860	45
Magnesium	924.12	500

(Source: Soil Resource Development Institute (SRDI), Khulna)

Appendix II. Analysis of variance of time of emergence, plant height, stem diameter plant^{-1}, number of leaves plant^{-1}, leaf length plant^{-1} and leaflet number leaf^{-1}

Source of variation	Degree of freedom (df)	Mean square						
		Time of emergence (days)	Life span of plant (days)	Plant height (cm)				
				27 DAP	42 DAP	57 DAP	72 DAP	87 DAP
Treatment	10	44.735**	59.97**	110.42**	210.11**	189.16**	199.81**	187.81**
Error	44	0.248	8.15	0.565	3.11	1.31	2.28	2.97

Appendix II continued…

Source of variation	Degree of freedom (df)	Mean square								
		Stem diameter plant^{-1} (mm)				Number of leaves plant^{-1}				
		27 DAP	42 DAP	57 DAP	72 DAP	27 DAP	42 DAP	57 DAP	72 DAP	87 DAP
Treatment	10	1.95**	1.47**	3.52**	2.33**	12.48**	41.88**	59.97**	71.75**	63.54**
Error	44	0.39	0.21	0.23	0.19	0.65	1.53	0.13	0.198	0.17

Appendix II continued…

Source of variation	Degree of freedom (df)	Mean square							
		Leaf length plant^{-1}(cm)				Leaflet number leaf^{-1}			
		27 DAP	42 DAP	57 DAP	72 DAP	27 DAP	42 DAP	57 DAP	72 DAP
Treatment	10	28.45**	57.15**	48.99**	36.27**	3.840**	5.699**	3.537**	2.277**
Error	44	0.47	0.56	0.74	0.52	0.031	0.103	0.071	0.112

Appendix III. Analysis of variance of leaflet length leaf^{-1}, leaflet breadth leaf^{-1}, number of main stem plant^{-1} and fresh weight of shoot plant^{-1}

Source of variation	Degree of freedom (df)	Mean square							
		Leaflet length leaf^{-1} (cm)				Leaflet breadth leaf^{-1} (cm)			
		27 DAP	42 DAP	57 DAP	72 DAP	27 DAP	42 DAP	57 DAP	72 DAP
Treatment	10	2.507**	3.517**	3.381**	2.304**	0.856**	0.897**	0.998**	0.969**
Error	44	0.029	0.043	0.044	0.058	0.016	0.028	0.037	0.046

Appendix III continued…

Source of variation	Degree of freedom (df)	Mean square	
		Number of main stem plant^{-1}	Fresh weight of shoot plant^{-1} (g)
Treatment	10	4.367**	252.955**
Error	44	0.187	0.471

Appendix IV. Analysis of variance of number of tuber plant^{-1}, tuber length, tuber breadth, weight of tuber container^{-1} and benefit cost ratio

Source of variation	Degree of freedom (df)	Number of tuber plant^{-1}	Tuber length (mm)	Tuber breadth (mm)	Weight of tuber container^{-1} (g)	Benefit cost ratio
Treatment	10	157.434**	158.198**	101.903**	96785.731**	1.234**
Error	44	0.480	26.484	28.254	84.509	0.000