EFFECT OF DRIP IRRIGATION OVER CONVENTIONAL METHOD ON THE GROWTH AND YIELD OF CHILI

A THESIS

BY

MST. HABIBA JESMIN PUSPHA

Student No: 1505291

Thesis Semester: July- December, 2017

MASTER OF SCIENCE (M.S)

IN

IRRIGATION AND WATER MANAGEMENT

DEPARTMENT OF AGRICULTURAL AND INDUSTRIAL ENGINEERING

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJAPUR-5200

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DEDICATED TO MY

BELOVED PARENTS

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ABSTRACT

A study was conducted in field at the Agricultural Research Farm in Hajee Mohammad Danesh Science and Technology, Dinajpur, during November 2016 to April 2017 to determine the effect of drip irrigation over the other conventional methods on the growth and yield of chili CV, namely BARI Morich-1. There were four irrigation treatment viz. control (T_0), furrow (T_1), boarder (T_2), and drip irrigations (T_3). The area sizes of land were 17.5 m^2. Four plants of one verity were transplanted in two rows alternatively in each plot. Irrigation water was applied at three growth stages viz. vegetative (0-30 DAT), flowering (36-60 DAT), and fruit development stages (65-100 DAT) based on field capacity and soil moisture depletion .From the experiment it was observed that about 100 to 150 % water could be saved in drip irrigation treatment as compared to other conventional methods. The yield of chili in drip irrigation was found 8.7tha^{-1}. The water productivity under treatments T_1, T_2 for BARI Morich-1 were found 11Kgm^{-3} and 14 Kgm-^{3} respectively.

ACRONYMS AND ABBREVIATIONS

BARI : Bangladesh Agricultural Research Institute

BBS : Bangladesh Bureau of Statistics

BCR : Benefit Cost Ratio

BINA : Bangladesh Institute of Nuclear Agriculture

Cb : Centi Bar

CV : Crop Variety

DAT : Days after Transplanting

DTW : Deep Tubewell

ET : Evapotranspiration

ET_0 : Reference Crop Evapotranspiration

FAO : Food and Agricultural Organization

GO : Government Organization

K_c : Crop Factor

Mha : Million Hectares

MIE : Minor Irrigation Equipment

MSL : Mean Sea Level

NGO : Non-Government Organization

NMIC : National Minor Irrigation Census

RSM : Response Surface Methodology

STW : Shallow Tube well

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CHAPTER I

INTRODUCTION

Chapter -I

INTRODUCTION

1.1 Background of the study

Water is one of the most important factors for crop production. The best seeds, fertilizer and plant protection measures will not appropriately fruitful if water is not available in sufficient quantity and at right time for the crop. Irrigation water may be applied to the field through conventional irrigation methods like furrow check basin. The evaporation, percolation, conveyance and seepage losses appear to be the major problems in obtaining a high efficiency of surface irrigation methods. The drip irrigation system seems to have overcome many of the problems faced by the conventional methods of application of irrigation water for specific soil, climate and cropping situation (Rao *et al.,* 1995).

1.2 Agriculture and irrigation in Bangladesh

Bangladesh is predominately an agricultural country with a total area of 14.39 million hectare of which 8.82 million hectare (66 percent) is under cultivation. Out of total cultivable land only 4.48 Mha (53%) is now under irrigation (NMIC, 2001). Irrigation facilities in the country started to develop during early 70's and about 12 percent (1.16 million ha) of total cultivable land was brought under irrigation during 1978 to meet full or potential demand (Bhuian, 1976).

Irrigation is the artificial application of water to the soil for the purpose of crop production. Irrigation water is supplied to supplement the water available from rainfall and contribution of soil moisture from ground water. Modern irrigation technology was introduced farmers need, used to irrigate their fields by lifting surface water through the traditional irrigation technologies like don and swing basket. After the introduction of minor irrigation equipment (MIE) in early 1960's many changes have been made over the period 1960 to 1989 (Jaim, 1993). Now in this millennium irrigation devices have reached a long distance, but still now their performance could not reach the satisfactory level. Now-a-days different GO, NGO, and local organizations are using DTW's and STW's for irrigation. (Awal et. *al.,* 2003).

Irrigation water is the vital input for optimum crop production but extremely dangerous if it contain toxic substances. Farmers sometimes test soil but they never test water for its quality. It is unknown to most of the farmers that utilization of low quality water for irrigation undoubtedly deteriorates soil productivity, which adversely affects crop production. Hence both quantity and quality should be taken into consideration for the success of irrigated agriculture.

1.3 Drip irrigation

Drip irrigation was developed as a sub-surface irrigation system applying water beneath the soil (Abdulla, 2003). The first such experiments began in Germany in 1869 where clay pipes were used in combination with drainage systems. The first reported work in the USA was made by House in Colorado in 1913 who indicated that the concept was too expensive for practical uses. Subsequent to 1920, perforated pipes were used in Germany, which made this concept feasible around the development of drip system using perforated pipes made of various materials (Howell *et al.,* 1980). Drip irrigation has not yet been used on a large scale for crop production in the Sudan. However it is used in green houses and privately owned small farms and gardens. Surveyed some areas in the Sudan, which are adapted to drip irrigation to produce valuable crops. Drip irrigation is the delivering slow frequent application of water in discharge points or line source with discharge of 2 to 100 liters per hour. Drip irrigation can be on the surface or sub-surface. The lateral pipe is preferred in high distance soils.

1.4. Chili and its importance as vegetable

Chili is the most essential and important spices crops in Bangladesh. The production of chili largely depends on the use of fertilizers, irrigation, pesticide etc. The Government of Bangladesh has, therefore, provided priority to the agriculture sector to increase the production of chili by giving subsidy to the farmers on different inputs such as seeds, fertilizer, irrigation etc. to achieve self-sufficiency in chili production. Farmers of Bangladesh are growing chilies following indigenous methods with the poor yield rate. The reasons behind such low yield due to lack of high yielding variety and method of production practices followed by the local growers. The yield of chili can be increased by adopting improve production technology like proper plant spacing, irrigation. Although chili is a major spice crop of Bangladesh, but its production technologies has not been standardized from the scientific and economic point of view. Therefore, research needs to bring improvement in production technologies as well as considering economic return chili crop of which an over whelming majority. of 330910 acres are owned land (76.11%) followed by 41231 acres of lease land (9.48%), 33270 acres of share crop land (7.65), 22862 acres of mortgage land (5.26%) and 6485 acres of other land (1.49%). The highest 112450 acres of land are in Dhaka division (25.87%) followed by 84683 acres of land in Chittagong (19.48%), 77406 acres of land in Rajshahi (17.80%), 77316 acres of land in Rangpur (17.78%), 42405 acres of land in Khulna (9.75%), 31546 acres of land in Barisal (7.26%) and 8950 acres of land in Sylhet division (1.82%) respectively. Out of the three varieties (BARI Morich-1, BARI Morich-2 and BARI Morich-3), local has the highest cultivation area of chili which is 79.09%. The second highest 16.77% of land is used for the Hybrid variety of chili. And the remaining land areas of 4.14% have been used for all other varieties of Chili. It is mentionable that 5.14%, 4.16%, 3.31% and 2.47% acres of land are used for Hybrid variety in Khulna, Chittagong, Dhaka and Rangpur division respectively whereas the remaining three divisions cultivate only 1.70% land for Chili. The average per acre leasing cost for chili crop in Bangladesh is Taka 8879. The cost of summer chili is found to be slightly higher by 2.54% than that of winter chili the average per kilogram production cost of chili in local variety is Taka 51.98; in hybrid variety is Taka 45.90 and in the other variety is Taka 53.17 respectively. In the summer season the lowest per kilogram production cost of hybrid variety is Taka 45.73 whereas local & other varieties are almost the same at Taka 50**.** On the other hand, in the winter season the highest per kilogram production cost for other variety is Taka 72.96 followed by local variety of Taka 53.22 and the hybrid variety of Taka 45.99 respectively (BBS).

Chili pepper (*Capsicum frutescence L.*) is a popular vegetable valued around the world for its color, flavor, spice, and nutritional value (Berke *et al.,* 2004). Capsaicin (8-methyl-N-vanillyl-6- none amide) and other caps crinoids give chili its fiery hot taste. Chili is rich in vitamin C and pro vitamin A, a good source of most B vitamins, particularly vitamin B6, and high in potassium, magnesium, and iron. Chili is grown throughout Cambodia, Laos, and Vietnam, Bangladesh, India, Pakistan and is an integral part of most meals, especially in Laos. It is *Green and ripe chili at harvest.* Eaten raw or added to various fresh and cooked dishes to provide the desired pungent or spicy taste; it is also added to processed products such as dried fruit, powder, or paste. Improved varieties and production systems combined with appropriate postharvest techniques to reduce waste and maximize use of the produce can increase the supply of chili for the fresh market and processing industries.

Chili is an important income generating crop and is well known mainly as a spices crop. Its demand is very high both in green and mature stages. Green chili contains more Vitamin C than ripened chili. About 60% yields could be losing due to improper time of weeding and management. At present, it occupies 1.05 lack hectares and produces about 1.76 lack metric tons (BBS, 2011).

The initial cost of the drip irrigation equipment is considered to be its limitation for large scale adoption. Economic consideration usually limits the use of drip irrigation system to orchard and vegetables in water scarcity areas. The cost of the unit and the net return from the crop should be compared before a decision is made on installing the drip irrigation. The main item of expenditure is the cost of the lateral lines. Crops like tomato, grapes, papaya, banana, chili and most other types of fruits and vegetables have been found to respond well in drip irrigation .There is considerable saving in water by adopting this method since the water

Could be applied almost precisely to the root zone and there is no need to wet the entire area between tree crops. Substantial increase in yields of vegetables crops have been observed by adopting the drip irrigation. The method reduces salt concentration in the root zone when irrigated with poor quality ground water. The application efficiency for drip irrigation is based on the water desired in the root zone. The total amount of water is less than the water requirement for whole area. The disadvantages of the system include the high initial cost, the equipments that the water must be relatively clear and the poor water distribution efficiency when a low pressure system is installed on steep slopes or uneven land.

Generally, chili crops are grown as rain fed and irrigated crop. If the crop is grown as rain fed one, a well distributed annual rain fall of 80 to 100 cm is required for better growth and yield. Chili plants are shallow rooted and cannot tolerate drought and flooding but need uniform and constant moisture in soil. In water scarcity areas, drip irrigation method is advised. However furrow method can also be adopted when enough water is present. Overhead irrigation should be avoided as this will promote diseases in chili cultivation. In case of heavy rain, make sure to drain out the soil quickly. If the plants grown on raised beds, there is a good chance of draining of water quickly.

First irrigation should be carried out after transplanting seedlings from nursery from two main fields. Subsequent watering should be provided once in 5 to 6 days in summer and once in 10 to 12 days in winter. Again, irrigation depends on soil type and climatic conditions. Flower and fruit drop occurs in chili cultivation, if the uniform moisture level is not maintained.

1.5. Objectives of the study

In view of the above mentioned importance, the experiment was conducted with the following objectives:

i. To determine the effectiveness of drip irrigation over other conventional irrigation methods for chili cultivation
ii. To find out the productivity of water in chili cultivation.

CHAPTER II

REVIEW OF LITERATURE

Chapter -II

REVIEW OF TITERATURE

This research has been undertaken to observe the effect of one winter vegetables chili *(Capsicum frutescence L.)* in drip irrigation system. Therefore, literatures related to the performance of crops in irrigation system and characteristics of tree species which were collected through reviewing of journals, thesis, internet browsing, reports, newspapers, periodicals and other form of publications are presented in this chapter.

A study was accomplished by Rao et *al.,* (1995) from Department of Irrigation Drainage, Faculty of Agriculture, and Hamadan, Iran. The purpose of the study to determine drip irrigation method. The drip irrigation is basically precise and slow application of water in the form of discrete continuous drops, sprayed through mechanical devices, called emitters into the root zone of the plant. The drip system of irrigation, water reaches the roots drop by drop and hence, it is an economic method of irrigation in all seasons. The problems analysis was reported based on the through studies of opinion survey of sample respondents adopting the drip irrigation system in study area. Thus, the generalizations of result are the feedback. The major constraints as perceived by the respondents are as per the frequency level of respondents and ranked accordingly the views at the time of collecting data were hard management practices in drip irrigation system.

The determination of impact of drip and surface irrigation on growth, yield and WUE (water use efficiency) of bell pepper carried by Antony et al. (2004). The experiment was laid out in randomized block design (RBD) with three replications. Irrigation treatments included surface IW/CPE (1.2, 1.0, 0.8 and 0.6) and drip (100, 80, 60 and 40). It was observed that 100% drip irrigation gave maximum yield in bell pepper grown in loamy soil of humid subtropical region. At 100% drip treatment plants had more height and more number of branches as compared to surface irrigated plants.

An experiment was done for water applications methods by Sharma (2006) to study the effect of three irrigation regimes (100%, 80% and 60% of crop water requirement) through drip and flood irrigation along with four mulches treatments (white, yellow, black and without mulch) on weed incidence and yield of capsicum F1 hybrid ‘Ingra’. It was reported that 60% water applied through drip along with black plastic mulch was most effective in quelling weed. While yellow plastic with 80% water applied through drip was moderately effective against quelling weed.

An effect of drip irrigation regimes on yield and quality of field grown bell pepper determined by Sezen (2007). Irrigation regimes consisted of three irrigation intervals based on three levels of cumulative pan evaporation values (I1, 18-22 mm; I2, 38-42 mm and I3,58-62 mm) were used. The maximum yield of 33.14 t/ha in the year 2002 and 35.3 t/ha in the year 2003 growing season was obtained from irrigation interval of 3-6 days and plant-pan coefficient of 1.0

An experiment was done for determination of water efficiency using plastic mulch by Ngouajio (2005) in India. The timing of drip irrigation initiation affects irrigation water use efficiency and yield of bell pepper under plastic mulch. Irrigation treatments were initiated at pepper transplanting (S0), after transplant establishment (S1), at first flower (S2), at first fruit (S3) and at fruit ripening (S4). The control treatment was received only enough water to apply fustigation (FT). Withholding irrigation did not affect pepper plant except FT treatment, but increased leaf chlorophyll content .Withholding irrigation until S4 saved 50% and 41% of irrigation started at transplanting. Irrigation water use efficiency was maximum at S4 (59.1 kg/ha mm) and S3 (24.1 kg/ha mm) in 2003 and 2004, respectively. Results revealed that withholding irrigation until first fruit may help to maintain pepper yield while reducing irrigation cost.

A study was accomplished by Lodhi (2008) from a field experiment in the Department of Soil and Water Engineering, PAU, Ludhiana in 2008-09 to study the effects of low tunnel environment on growth and yield of drip irrigated sweet pepper (*Capsicum annum)* The experiment was laid out in split plot design keeping five irrigation treatments (drip irrigation with IW/CPE ratio of 0.60(I1), 0.75(I2), 0.90(I3), furrow irrigation with paired row planting (I4) and single row planting(I5), in main plots and replicated three times. There was also significant effect of irrigation, tunnel height and their interaction on number of fruits per plant, fruit length, sweet pepper yield and WUE .Highest economic returns were achieved in 75 cm low tunnel height drip irrigated with IW/CPE ratio of 0.75.

A study was accomplished by Kathun (2010) at Bangladesh Agricultural University. Mymensingh in poly bags under glasshouse condition during October 2009 to March 2010 to know the effects of different water levels at different growth stages of four selected chili accessions. The results revealed that all the studied parameters viz., plant height, canopy diameter, root length, root volume, no. of fruits per plant, fruit length, fruit diameter, individual fruit weight, no. of leaves per plant, leaf area per plant, fruit yield per plant, leaf dry weight, stem dry weight, root dry weight, fruit dry weight per plant, varied significantly among the accessions under different water treatments at different stages of growth. Out of four accessions, C-0271 and C-0277 were found as water stress tolerant and susceptible, respectively.

A Field experiments were conducted by *Murugappan* (2010) to evaluate the effect of site specific drip fustigation in completely randomized design (CRD) with six treatments and four replications. Hybrid chili (hot line) was used as the test crop. Drip irrigation was scheduled daily (24 hrs) and once in two days (48 hrs) based on the treatments with the computed quantity of water.. The different yield parameters like fruit length, fruit girth, fruit weight and number of fruits per plant also varied in the same trend as that of total green fruit yield. In case of low fertility area, highest BCR was obtained for the treatment site specific drip fustigation and daily drip irrigation (2.42) followed by the treatment site specific drip fustigation and alternate day drip irrigation (2.25). The lowest BCR was obtained under the treatment with manual application of fertilizer and alternate day drip irrigation (1.91). In case of high fertility area, corresponding values of BCR were 2.47. 2.43 And 2.17 respectively.

A crop water requirement of some crops are determined by Abdulmumin (2009) using hydraulic weighing lyses meters; these crops were sorghum, chili, maize, groundnut and millet. Crop water requirement of pepper was determined by using two drainage lyses meters for one week period in the region of Almeria, Spain. Crop water consumption of any crop increases linearly as the crop grew and shows a slight reduction at maturity. As the researched result of pepper showed that the seasonal crop water requirements of pepper were 362 mm.

A study was accomplished by Bosland (1999) studied two varieties sweet pepper and hot pepper, like capsicum and chili and its effects on the growth, yield and maturity stage. It has been found that as hot peppers mature, the Pro-vitamin A (B Carotene) and ascorbic acid increase. This has led to extensive production of hot peppers in some countries for export markets. A substantial percentage of pepper acreage in the largest producing countries is dedicated to chili powder. However, the higher prices received by farmers for fresh products have helped sustain the vegetative pepper industry, despite rising production costs competition and increased demand. This increasing demand for pepper to feed the growing human population and supply the ever-expanding pepper industries at national and international level has created a need for the expansion of pepper cultivation in to areas where it has not ever been extensively grown.

A study was accomplished by Kallo (1986) from "Effect of INM practices on plant growth, fruit yield and yield attributes in chili". To study the effect of Organic matter, Bio-fertilizers in combination of photo hormones on Growth and yield in chili during Kari season at student farm of department of vegetable science of college of agriculture. Application of organic matter RDF recorded higher plant height (70.6, 86.6, 99.0, 99.7cm. in Azad mirch-1 and 66.8, 72.8, 85.0, 85.9 cm at 60, 90, 120 Days and at harvesting. The fruit yield were also recorded significantly higher (201.99 and 145.32) g/plant in chili respectively over control.

In a study the economics of cost of production in chili for drip and conventional irrigation method in middle Gujarat by Patel (1999). The data were collected from 120 green chili producing farmer from 12 villages of 4 talkies of 3 district of middle Gujarat, out of that 60 drip irrigated farmers and 60 conventional irrigated farmers. The average total cost of cultivation for drip irrigation method and conventional irrigation method per hectare was about 126432, 124713 and respectively. The net profit per hectare in drip irrigation system was 322265 while in case of conventional irrigation system it was 250111. The total cost of production for drip and conventional irrigation methods were found `310.18 and `341.86 per quintal, respectively. The input output ratio for drip and conventional irrigation system was calculated on the basis of cost were found 3.58 and 3.15 respectively.

A field experiment was conducted by Pandey (1999) to investigate the effect of drip irrigation, spacing and nitrogen fustigation on yield of Capsicum. The results revealed that drip irrigation enhanced the fruit yield, net income and minimized the time, weeds and diseases of the crop. Closer spacing at 30 cm produced higher yield (58.77%) and net income as compared to 45 cm spacing. Fustigation resulted in maximum yield (10.20 kg/m2), minimal disease and saved water and total irrigation time as compared to top dressing. The drip irrigation had significantly increased yield (10.50 kg/m2) and net income (60.30%) as compared to flood irrigation.

A field experiment was conducted by Sharma (2002) to determine the effect of drip irrigation and nitrogen fustigation on guava crop. The result showed that water use efficiency (WUE) was greatly influenced by drip irrigation and nitrogen fustigation. Maximum WUE (35.1 kg/ha-mm) was noted in the treatment which was irrigated with drip at 80% ETC. The lowest WUE (23.2 kg/ha-mm) was noted in the conventional irrigation system.

A field experiment conducted by Kaushal (2005) to study the economics of growing sweet pepper under low tunnels. The experiment was laid out in split plot design keeping four irrigation treatments (drip irrigation with IW/CPE ratio of 0.60 (I1),0.75(I2) ,0.90 (I3) and furrow irrigation with paired row planting (I4), in main plots and three different low tunnel heights (45 cm (H1)),60 cm (H2) and (75 cm (H3)) in sub plots and replicated three times. The treatment combination of I2H2 treatment gave maximum benefit-cost ratio (2.93 without subsidy) and (3.05 with maximum subsidy) in drip irrigation.

Kaushal and Singh *et al.,* (2006) carried out field evaluation of drip irrigation at farmers field in Hoshiarpur district of Punjab. Water saving/scarcity of water, yield increase, labor saving, decrease in weed growth, energy saving, quality improvement, subsidy available and uniform irrigation were the major factors associated with adoption of drip irrigation as reported by 75-100 per cent of the farmer.

A field experiment was done to study the effect of different levels of irrigation and fustigation on drip irrigated (*Capsicum frutescent L.*) by Singh (2010) . The experiment was laid out in split plot design keeping three fustigation treatments (100(F_1), 80 (F_2) and 60 (F_3) % of recommended fertilizers) in main plots and three irrigation treatments (drip irrigation with 1.0 (I_1), 0.8 (I_2) and 0.6 Potential evaporate-transpiration (PET) (I_3) in sub plots. Better results were found in case of drip irrigation treatments as compared with CT (conventional treatment). The gross income from drip irrigation system and CT was Rs.283905/ha and Rs.230475/ha respectively. Higher benefit cost ratio in case of drip irrigation system (2.55:1) as compared to CT (2.07:1) suggests better returns from drip irrigation system.

A reported that the subsidy and technical support to farmers acts as an incentive to adopt drip irrigation on a large scale in India by Kaushal (2001) . The benefit-cost (B: C) ratio was maximum (2.84) in drip fustigation.

A field experiments was conducted by Ramah (2007) in the year 2006-07 at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore to study the effect of varying irrigation regimes and fertilizer levels in maize based cropping system. The experiment was laid out in split plot design keeping three irrigation regimes in main plots viz., I1 - Drip irrigation at 75 % Wrack (computed water requirement of crop), I2 - Drip irrigation at 100 % Wrack, I3 - Drip irrigation at 125 % Wreck and four fertilizer levels in sub plots viz., F1 - 75 % RDF, F2 - 100 % RDF, F3 - 125 % RDF and F4 - Drip irrigation

+ 100 % RDF by soil application. The gross income (Rs. 3, 09, 554) was higher in the treatment with 100 per cent Wrack with 125 per cent RDF whereas, higher benefit cost ratio of 4.07 was recorded by drip irrigation at 100 per cent Wreck with soil application of RDF. Drip irrigation at 75 per cent Wreck with 125 per cent RDF (I1F3) recorded higher net profit per mm of water used (Rs. 274), which was followed by same irrigation regime with 100 per cent RDF.

In a study nitrogen and phosphorus efficiency on the fruit size and yield of chili was done by Rao (1995). Four levels of N (0, 50,100 and 150 kg/ha) and three levels of P (0, 30 and 60 kg/ha) treatments were given. Length and width of fruit and number of fruits per plant increased significantly with increasing nitrogen doses up to 100 kg N /ha .However, average weight of fruit content increased significantly with increasing levels of P up to 150 kg N/ha. Average weight of fruit and yield increased significantly with increasing levels of P up to the treatment 30 kg P /ha, whereas length of fruit and number of fruits per plant was increased significantly up to the 60 kg P /ha .Considering the combined effect of Nitrogen and Phosphorus, the maximum significant length of chili, width of chili, number of fruits per plant and average weight of fruit as well as yield were found in the treatment combination of 150 kg N and 30 kg P /ha.

A study conducted fustigated by Marcussi (1993) to study the macronutrients accumulation and portioning in fustigated hot pepper plants. Experiment was laid out in a randomized block design with four replications. The period of largest extraction of nutrients for the plant occurred from 120 to 140 (days after the seedling transplant) DAT, which coincides with the highest accumulation of dry photo mass. The highest Mg and Ca accumulation occurred in the leaves while N, K, S and P were mostly accumulated in fruits. Only 8 to 13% of the total amount of accumulated macronutrients at 140 DAT were observed macronutrients (60% of the macronutrients accumulated during the whole cycle). Phosphorous, Calcium and Subpar were the most absorbed nutrients at the end of cycle.

The effect of different nitrogen-phosphorus-potassium (NPK) dosage applied by fustigation and two types of irrigation water on the soil plant system of a pepper crop observed by Contreras (1994) . Six different treatments were established, three rates of NPK (0, 50 and 100% of total concentration extracted by the crop) applied by fustigation and two types of water (0.7 and 2.6 do m-1). The crop showed a positive response to an increase of NPK concentration solution.

The response of fustigation on capsicum growth under naturally ventilated tropical greenhouse studied by Kamaruddin (1987). A fertilizer recipe by using a cooper formulation was developed and tested for capsicum growth under green house in the lowlands. Capsicum of big star variety was planted in the coco peat media. Water with fertilizer solution was automatically supplied to the root zone for 20 minutes, 6 times per day .The performances of capsicum growth in term of stem diameters, plant height and leaf width against time were measured. The relationship between leaf and stem growth against time were found to be linear, while the height versus time was exponential.

An experiment to study the comparative performance of drip irrigation and fustigation over conventional methods of irrigation and fertilizers application in Chili conducted by Gupta (2006) . The experiment consisted of 16 treatment combinations replicated four times. The treatments include 4 levels of irrigation viz., 100%, 80% and 60% ET through drip and 100% surface irrigation; and four levels of fustigation viz., 100%, 80% and 60% recommended NPK through fustigation and 100% recommended NPK through manual. Surface irrigation and manual fertilizers application were treated as control of the crop root zone. It was further concluded that by adopting drip irrigation system, the highest income of Rs. 2, 82, and 026/- could be generated in chili as against Rs. 1, 69,990/- realized under conventional method. Benefit cost ratio was also noticed maximum (3.33: 1) with the same treatment combination i.e. 80% ET through drip + 80% recommended NPK through fustigation.

CHAPTER III

MATERIAL AND METHODS

Chapter -III

MATERIALS AND METHODS

3.1Experimental site

The experiment was conducted at the Hajee Mohammad Danesh Science & Technology University (HSTU) Farm, Dinajpur (latitude $25^0 37^{'} 16^{''}$ N, longitude $88^0 38^{'} 4^{''}$ E, altitude 37 m above mean see level) during 10th November /2016 and 30^{th} April .

3.1.1 The climatic condition

The climatic zone of the study area is wet, characterized by a winter season. The soil characteristics data for HSTU, Dinajpur as shown in appendix-I

3.2 Land preparation

The experimental land was first opened on November 2016 and the operation was done by spade. Then the land was fallow for few days. All crop residues and weeds were removed from the field and finally the land was properly leveled

3.2.1 Physical properties of the land

The soil of the experimental land was prepared by several ploughing. Bulk density of soil was measured , value was found to be 1.42 gm/cm^3. The texture of the soil determined by hydrometer method was found to be clay loam. The volumetric field capacity was measured as 45 percent.

3.2.1 Experimental design and treatment

The experiment was carried out by randomized block design (RCBD) as given below:

Fig-3.1: RCBD design of chili shown in following figure

T_1R_1	**T_2 R_1**	**T_0 R_1**	**T_3 R_1**
T_0R_2	**T_3 R_2**	**T_1 R_2**	**T_2 R_2**
T_1R_3	**T_2 R_3**	**T_0 R_3**	**T_3 R_3**

There were four treatments for the experiment as stated below:

T_0=Control(No irrigation)

$T_{1=}$Furrow irrigation up to field capacity at vegetative, flowering and fruit development stages

T_2=Irrigation with border method up to field capacity at, vegetative, flowering and fruit development stages

T_3=Drip irrigation using saline bag at vegetative, flowering and fruit development stages

3.3 Land preparation and transplanting

The soil of the research field was prepared by several tillage practices and several cross plouging by spade. Transplanting , each land was fertilized uniformly with recommanded basal dose of 600kg P_2O_5 ha^{-1} as TSP, 500 kg Nha^{-1} as urea, 200 kg K_2O ha^{-1} as MOP and 10,000 kg ha^{-1} as cowdung.

Before land preparation ,soil samples were collected as depth up to 30 cm to know the moisture content in the soil. Thirty five days old seedling of chilli varietie BARI Morich -1 were transplanted on the 9^{th} November 2016 in two rows . There were two plants in each row.

3.4 Intercultural operation

Weeding were done at 30 days after transplanting. As the stem and branches were elongating, staking were given to each by bamboo stick to keep them erect. Each plant was marked with an identifying number.

3.5 Application of irrigation water

Irrigation water was applied as per schedule of the irrigation treatment expect the control land. Before irrigation , soil moisture was calculated at each stage of the crop by gravimetric method. The depth of irrigation water was calculated using the following equation .

$$d = (FC-M /100) \times 15 \times \text{bulk density}$$

Where,

d = irrigation water depth (cm)

FC = field capacity (% vol.)

M = percent moisture content (volume basis)

Bulk density of soil (gm/cm^3)

Fifteen is the detonated soil depth for every 15 cm increment up to 60 cm. This depth (d) was multiplied by the area of plot to get the volume of water.

3.6 Growth stages of chilli

During the study, the growth stages considered for observation of yield were vegetative (0-30 days) , flowering (35-60 days) and fruit development (65-100 days).

3.7 Soil moisture measurement

Soil moisture content in each plot was measured by gravimetric method up to 60 cm depth for every 15 cm increment at the time of trasplanting , before and after each irrigation and at the end of the growth stages, and at the time of harvest .

Table-3.1: Chronology of different activities during the growing season

SI NO.	ACTIVITIES	DATE
1.	Land preparation and application of basal fertilizer	5.11.2016
2.	Transplanting of plant	9.11.2016
3	Weeding	9.12.2016
4.	Irrigation	
	Vegetative stage	1.12.2016
	Flowering stage	2.1.2017
	Fruit development stage	20.2.2017
5.	Harvesting	From 6.3.17-30.4.17
6.	Dry weight of stem	10.5.2017

3.8 Harvesting

Fruits were harvested at 5 to 7 days interval during early maturing stage when were of attainable green colour. Harvesting was started on the 6 March 2017 up to 30 April 2017 which are shown in Appendix –(VI & IX)

Photographic representation of the reserch field of chili

Fig-3.2: Land Preparation

Fig-3.3:Cowdung Application

Fig-3.4: Seedlings Transplanting

Fig-3.5: Research Field of Chili

Fig-3.6: Contol Irrigation

Fig-3.7: Furrow Irrigation

Fig-3.8: Border Irrigation

Fig-3.9: Drip Irrigation

Fig-3.10: Harvesting

Fig-3.11: Green Chili

3.9 Collection of agronomic data

Data on the following parameters were recorded from each plant during the course of experiment.

3.9.1 Plant height

Plant height was measured from the sample plants in centimeters (cm) from the growth level to the tip of the longest stem and mean value was calculated. Plant height was recorded 15 days interval starting from 20 days of transplanting up to 65 days to observe the growth rate of plants. Lastly plant height was recorded at final harvest,number of primary branch and number of harvested secondary branch also recorded .

3.9.2 Days of first flowering

Different dates of flowering were recorded. The observation was recorded from the date of transplanting.

3.9.3 Number and weight of chili per treatment plot

Chili number was calculated manually and the weight of chili per treatment plot was taken by using a pan scale balance . The chili weight of each harvest was recorded separatrly for a particular plot and all weights from first to final harvest were combined together to get the total yield for the same plot. The number of harvested chili , weight of harvested chili and dry weight of straw were recorded .

3.10 Data analysis

The recorded data were compiled and analyzed to find out the statistical significance of the experimental results. The means for all recorded data, the analyses of variance for all the characters and Least Significant Difference (LSD) test were performed using statistical package programmed SPSS version-22.0.

CHAPTER IV

RESULTS AND DISCUSSION

Chapter-IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the effect of drip irrigation over conventional method on the growth and yield of chili. The result of each parameter studied in the experiment have been presented and discussed under the following headings.

4.1 Growth of chili plant

To observe the growth of chili plant due to different irrigation treatment i.e., no irrigation, furrow, border, drip, the plant height was recorded different days after transplanting (DAT). For all the treatments, it was observed that the plant height increased gradually with the advancement of times as shown in Fig-4.1, Table-4.1. The impact of different irrigation methods on primary branch, secondary branch and stem yields is shown in Table-4.2. It was observed that the trend of highest primary, secondary branches and stem yields were T_3.

Table-4.1: Plant height of the selected chili plants under different irrigation treatments

Treatments	Plant height(cm)				
	20 DAT	35 DAT	50 DAT	65 DAT	120 DAT
T_0	$3.5±0.26^a$	$7.0±2.29^a$	$10.0±3.04^a$	$12.0±2.64^a$	$15.0±2.64^a$
T_1	$6.0±2.09^a$	$15.0±3.0^b$	$21.0±2.0^b$	$25.0±1.0^b$	$35.0±3.60^b$
T_2	$14.0±2.0^b$	$22.0±3.0^c$	$25.03±.55^b$	$30.0±1.73^c$	$38.0±2.64^b$
T_3	$15.0±1.0^b$	$23±3.0^c$	$30.0±2.92^c$	$38.0±1.10^d$	$43.0±1.25^c$

Table- 4.2: Primary and secondary branch and dry weight of stem

Treatment	Plant No.	Primary branch (no.)	Secondary branch (no)	Dry weight of stem (gm)
T_0	1	2	3	45
	2	2	4	78
	3	3	2	60
	4	2	3	80
T_1	1	2	3	85
	2	2	5	80
	3	3	4	102
	4	2	5	115
T_2	1	2	3	150
	2	3	2	105
	3	2	3	100
	4	2	4	120
T_3	1	2	6	160
	2	2	4	135
	3	4	6	120
	4	2	4	105

The average dry weight of stem in control, furrow, border and drip irrigation were found 65.75 gm, 95.50 gm, 118.75 gm, 130gm. The dry weight of stem was low at control irrigation and comparatively high at drip irrigation. In drip irrigation method, it may be chili plant water intake was high.

4.2. Plant height at different days after transplanting

Application of different irrigation methods showed the variation of plant height (appendix II-V). The plant height varied from 3cm to 44 cm. The highest plant height was recorded in the treatment T_3 (44cm) under drip irrigation method which was closely followed by T_2 (41cm) under border irrigation. The highest plant height showed in drip irrigation might be due to water application at plant root zones slowly its field capacity. The plant height lowest as control irrigation might be no water application in field.

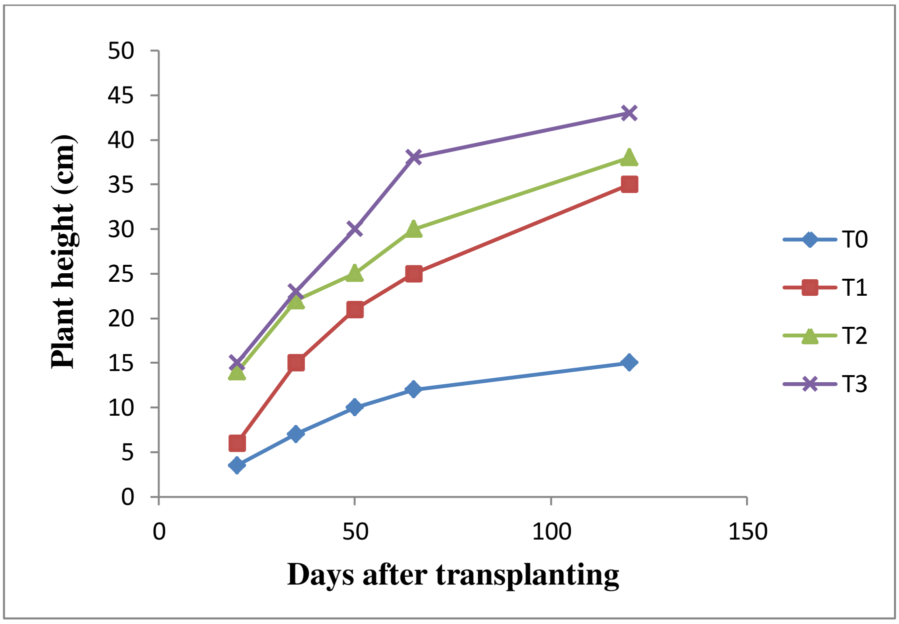

Fig-4.1: Effect of different irrigation treatments on plant height at different DAT for BARI Morich-1

4.3 Yield and water use of chili

The number of fruits and the corresponding weight, yield, number of irrigation, amount of irrigation water applied, irrigation water savings and water productivity for both the varieties under various treatments are presented in table 4.3

Table-4.3: Yield and water use of chili

Treatments	No. of fruits	Weight (Kgm^{-2})	Yield ($t\ ha^{-1}$)	No. of irrigation	Irrigation water applied		Excess water needed than T_3 (%)	Water Productivity (Kg/m^3)
					Depth (cm)	Vol^m (m^3)		
T_0	42.66±9.29[a]	0.05±.01[a]	0.5	0	0	0	-	-
T_1	708.00±75.66[b]	0.83±.09[b]	8.3	3	6.57	657	112	11
T_2	741.33±43.66[b]	0.90±.02[b]	9.0	3	7.52	752	143	14
T_3	777.66±47.18[b]	0.87±.02[b]	8.7	3	3.1	310	-	30

4.4. Yield of Chili

Chili yield per hectare is the outcome of collectively of various yield components, which is affected by different growing condition and crop management practices. The yield of BARI Morich-1 was significantly influenced by the different irrigation methods. Application of different irrigation methods showed that the variation for chili yield Table- 4.3 and Appendix-(VI-IX). The yield of chili varied from0.5 ton $ha^{-1}$to 9.0 ton ha^{-1} .It can be seen from Table- 4.3 that the highest fruit yield of 9.0 tha^{-1} was obtained under treatment T_2 (border irrigation) this may be due to water available surrounding the plot which was released water for proper growth period of chili plant. The yield of chili of other treatments T_4 (drip irrigation) 8.7 ton ha^{-1}, T_1 (furrow irrigation) 3 ton ha^{-1} and T_0 (control) 0.5 ton ha^{-1} in order. The highest yield was in boarder irrigation (9 tha^{-1}) and lowest yield in control irrigation (0.5 tha^{-1}) Fig-4.2

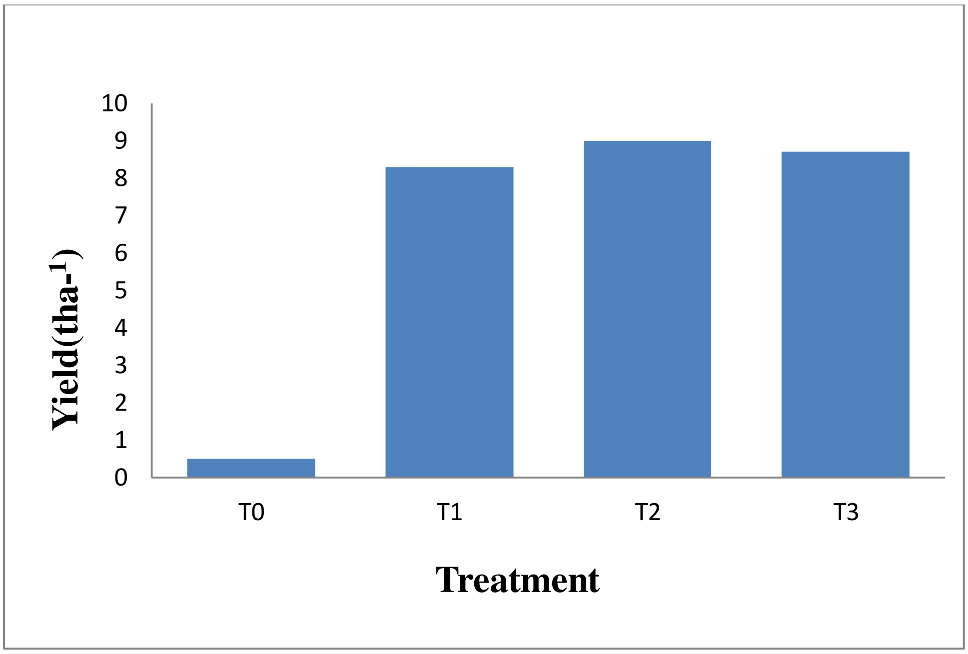

Fig-4.2: Yield of different irrigation treatments

4.5. Water requirement of chili

It was evidenced that except control irrigation, irrigation was imposed at the three selected growth stages (vegetative, flowering and fruit development) in other all treatments, but only the approaches were different. So, the number of irrigation was same (3 Nos.) for treatment T_1 to T_4. As the depleted soil moisture was fulfilled to the field capacity, varying amount of water was needed for different treatments. The highest water requirement in border irrigation method was 752 m^3 showed in Fig. 4.3.

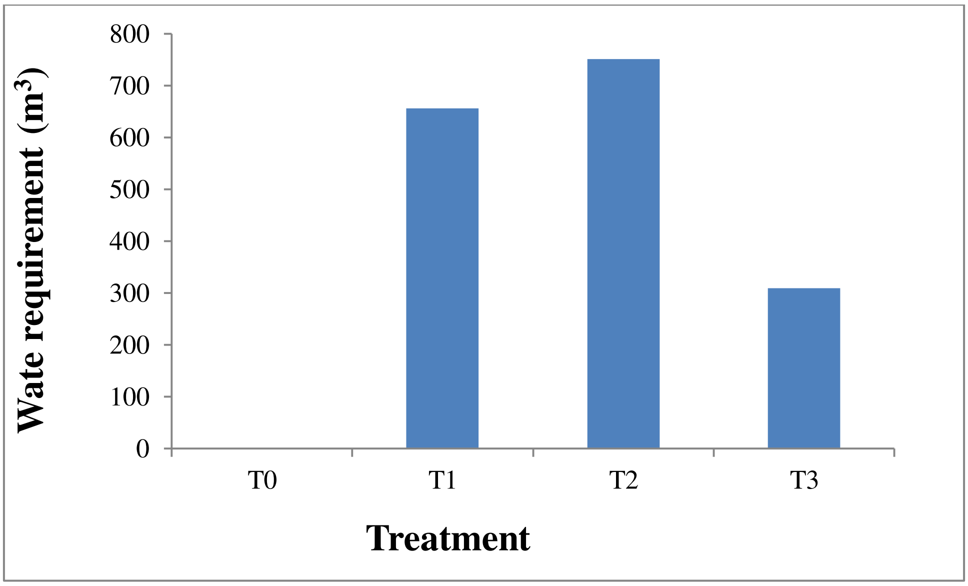

Fig-4.3: Water requirement per hectare of different irrigation treatment

The highest amount of water needed was 7.52 cm in T_2, followed by 6.57 cm in T_1 and 3.1 cm in T_4 (drip method). Thus the drip saves about 112%, 143 % compared to furrow (T_1) and border (T_2) irrigation methods respectively. It also showed that roughly about one third (1/3) amount of water was applied in drip irrigation method producing nearly equal or more yield compared to the other methods. Hence, compared to drip irrigation method, yields were not increased in other methods in proportion to their water required. Thus, drip irrigation method seemed to be the best water saving technique for obtaining reasonably higher yield. Further, converting the applied water to per hectare volumetric content, it can be seen that, the minimum water (220 m^3) was required in treatment T_4 (drip irrigation) which made the highest water productivity of 30 Kgm^{-3} for BARI Morich-1(Fig-4.4). From the same Fig-4.4 it appears that the lowest water productivity of 14Kgm^{-3} resultant from treatments T_2, because of higher irrigation requirement of 752 m^3.

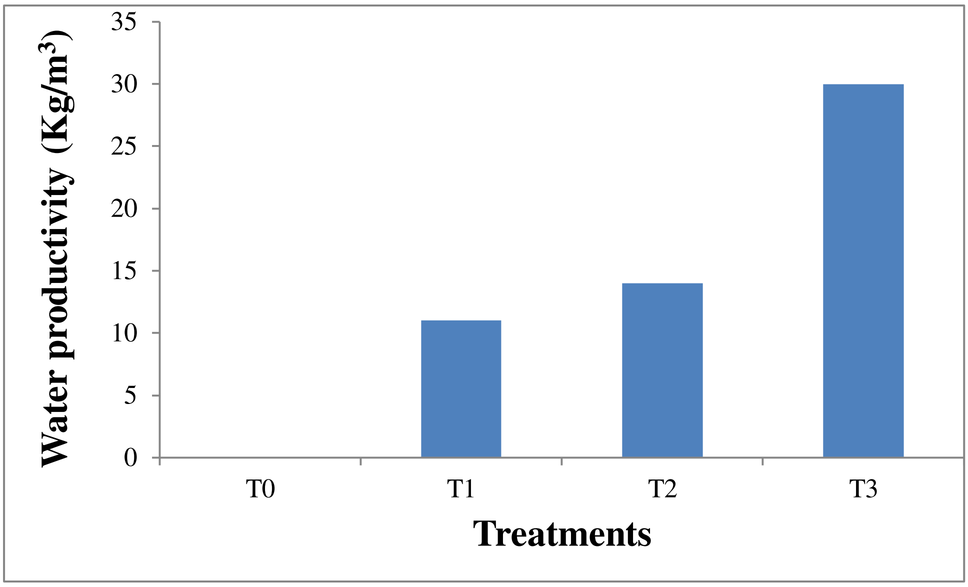

Fig.-4.4: Water productivity of different treatments

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Chapter- V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The experiment was conducted at the Hajee Mohammad Danesh Science & Technology University (HSTU) farm; Dinajpur during November 2016 to April 2017 On the basis of the experimental findings, the followings conclusions may be drawn: A sustainable amount of irrigation water 36 percent can be saved through drip irrigation without hampering the yield of chili. Drip irrigation requires only 310 m^3 of water (about one third) for chili compared to other methods. Chili can be grown having a reasonably yield under residual soil moisture condition. The yield of chili were 0.5, 8.3, 9.0, 8.7 t/ha for control, furrow, boarder and drip irrigation method. The yield of chili in different irrigation methods were T0 $<T_1<T_3<T_2$ in relation. However, the yield of chili was higher at boarder irrigation method but the water productivity of drip irrigation was higher for BARI Morich-1 30 Kg/m^3. The volume 310 $m^3$of water saves in drip irrigation compared to other methods.

5.2 Recommendations

The following recommendations may be put forward for future research work:

i. The studies may be repeated for several years to confirm the results.

ii. Studies need to be conducted at different agro-ecological zones of Bangladesh for exact quantification of irrigation need for different irrigation methods under variable climatic conditions.

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APPENDICES

APPENDICES

Appendix-I Soil properties of the experimental sites of the study area during 2015- 2016 (Before sowing of chili)

Soil depth (cm)	P^H	OM (%)	Total N (%)	P (mg/gm soil)	K (mg/100g soil)	S (mg/gm soil)	Zn (mg/gm soil)	B (mg/gm soil)
0-10	6.2	2.33	0.12	36.47	0.19	10.81	0.88	0.22
10- 20	6.83	1.49	0.08	23.99	0.12	12.16	0.68	0.28
20-30	7	1.60	0.08	13.93	0.14	12.76	0.57	0.23
Avg	6.68	1.81	0.09	24.8	0.15	11.91	0.68	0.25

Appendix-II Plant height at different days after transplanting (treatment T_0)

Treatments	Plant height (cm)		
	Plant height from each replication	Average	DAT
T_0	3.8	3.5	20
	3.4		
	3.3		
	7.5	7	35
	9.0		
	4.5		
	11.5	10	50
	12.0		
	4.50		
	13	12	65
	14		
	9.7		
	17	15	120
	16		
	12		

Appendix-III Plant height at different days after transplanting (treatment T_1)

Treatments	Plant height (cm)		
	Plant height from each replication	Average	DAT
T_1	6.5	6	20
	3.7		
	7.8		
	12	15	35
	15		
	18		
	19	21	50
	21		
	23		
	24	25	65
	25		
	26		
	31	35	120
	36		
	38		

Appendix-IV Plant height at different days after transplanting (treatment T_2)

Treatments	Plant height (cm)		
	Plant height from each replication	Average	DAT
T_2	16	14	20
	12		
	14		
	22	22	35
	25		
	19		
	25.6	25	50
	24.5		
	25.0		
	31	30	65
	28		
	31		
	37	38	120
	41		
	36		

Appendix-V Plant height at different days after transplanting (treatment T_3)

Treatments	Plant height (cm)		
	Plant height from each replication	Average	DAT
T_3	16	15	20
	15		
	14		
	20	23	35
	25		
	26		
	36.0	38	50
	32.7		
	38.0		
	31	30	65
	39.1		
	31		
	42.9	43	120
	43.0		
	44.3		

Appendix-VI Harvesting activities at different days (Treatment T_0)

Date	Plot No.					
	1		2		3	
	No.	Wt (gm)	No.	Wt (gm)	No.	Wt (gm)
6/3/17	-	-	-	-	-	-
13/3/17	5	9	15	18	6	8
20/3/17	-	-	8	9	-	-
27/3/17	8	12	-	-	19	21
3/4/17	6	8	6	8	10	15
10/4/17	12	9	14	17	12	15
17/4/17	-	-	6	7	-	-
24/4/17	-	-	-	-	-	-
30/4/17	-	-	-	-	-	-
Grand Total	32	38	49	59	47	59

Appendix-VII Harvesting activities at different days (Treatment T_1)

Date	Plot No.					
	1		2		3	
	No.	Wt (gm)	No.	Wt (gm)	No.	Wt (gm)
6/3/17	-	-	-	-	-	-
13/3/17	47	55	55	60	70	83
20/3/17	50	56	43	50	50	52
27/3/17	80	85	85	90	100	120
3/4/17	120	135	200	240	170	200
10/4/17	150	180	88	104	97	112
17/4/17	60	77	72	90	90	103
24/4/17	68	80	52	65	132	160
30/4/17	48	55	160	185	59	67
Grand Total	623	723	733	884	768	897

Appendix-VIII Harvesting activities at different days (Treatment T_2)

Date	Plot No.					
	1		2		3	
	No.	Wt (gm)	No.	Wt (gm)	No.	Wt (gm)
6/3/17	-	-	-	-	-	-
13/3/17	48	55	52	65	60	72
20/3/17	84	103	88	98	50	65
27/3/17	80	85	85	90	100	120
3/4/17	150	180	200	240	175	204
10/4/17	150	180	87	105	112	140
17/4/17	95	113	140	165	98	120
24/4/17	65	90	52	65	110	140
30/4/17	54	74	65	83	59	67
Grand Total	721	880	769	928	764	911

Appendix-IX Harvesting activities at different days (Treatment T_3)

Date	Plot No.					
	1		2		3	
	No.	Wt (gm)	No.	Wt (gm)	No.	Wt (gm)
6/3/17	-	-	-	-	-	-
13/3/17	105	115	88	100	115	133
20/3/17	88	93	109	120	130	150
27/3/17	154	160	130	143	100	120
3/4/17	93	110	175	190	120	120
10/4/17	100	120	50	66	112	140
17/4/17	89	100	66	85	40	55
24/4/17	65	82	86	107	118	130
30/4/17	48	62	55	83	97	110
Grand Total	742	842	759	894	832	888