EFFECT OF AGE OF SEEDLINGS AND NUMBER OF PLANTS PER HILL ON THE GROWTH AND YIELD OF ONION

MST. SONIA SULTANA

DEPARTMENT OF HORTICULTURE
SHER-E-BANGLA AGRICULTURAL UNIVERSITY
DHAKA-1207

JUNE, 2015

EFFECT OF AGE OF SEEDLINGS AND NUMBER OF PLANTS PER HILL ON THE GROWTH AND YIELD OF ONION

BY

MST. SONIA SULTANA
Reg. No.: 09-03652

A Thesis

Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka
in partial fulfilment of the requirements
for the degree
of

MASTER OF SCIENCE (MS)

IN

HORTICULTURE

SEMESTER: JANUARY-JUNE, 2015

Approved by:

……..…..…..……..…….…..…	…....…..……..
Assoc. Prof. Dr. Khaleda Khatun	**Prof. Md. Ruhul Amin**
Department of Horticulture	Department of Horticulture
SAU, Dhaka	SAU, Dhaka
Supervisor	**Co-supervisor**

……..……

Assoc. Prof. Dr. Tahmina Mostarin
Chairman
Examination Committee

DEPARTMENT OF HORTICULTURE
Sher-e-Bangla Agricultural University
Sher-e-Bangla Nagar, Dhaka-1207

CERTIFICATE

This is to certify that the thesis entitled, ***"Effect of age of seedlings and number of plants per hill on the growth and yield of onion"*** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in the partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (MS) in HORTICULTURE,** embodies the result of a piece of *bona fide* research work carried out by ***MST. SONIA SULTANA,*** Registration No. ***09-03652*** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed during the course of this investigation has been duly acknowledged and style of this thesis have been approved and recommended for submission.

Dated: June, 2015
Dhaka, Bangladesh

Dr. Khaleda Khatun
Associate Professor
Department of Horticulture
Sher-e-Bangla Agricultural University
Dhaka-1207
Supervisor

DEDICATED

TO

MY BELOVED PARENTS

ACKNOWLEDGEMENTS

At first the author expresses her profound gratitude to Almighty Allah for his never-ending blessing to complete this work successfully. It is a great pleasure to express her reflective gratitude to her respected parents, who entiled much hardship inspiring for prosecuting her studies, thereby receiving proper education.

The author would like to express her earnest respect, sincere appreciation and enormous thankfulness to her supervisor, ***Assoc. Prof. Dr. Khaleda Khatun****, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for her scholastic supervision, continuous encouragement, constructive suggestion and inspiration throughout the research work and for taking immense care in preparing this thesis, without her intenxe co-operation this work not have been possible.*

The author wishes to express her gratitude and best regards to her respected Co-Supervisor, ***Prof. Md. Ruhul Amin****, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his cooperation, encouragement and valuable suggestions during the entire period of course and research work and preparation of this thesis.*

The author is highly grateful to her honorable teacher ***Assoc. Prof. Dr. Tahmina Mostarin,*** *Chairman, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for her valuable teaching, encouragement and cooperation during the whole study period.*

The author feels to express her heartfelt thanks to her honorable teachers of the department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for their valuable teaching, direct and indirect advice, encouragement and cooperation during the period of the study.

The author is thankful to all of the academic officers and staff of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for their continuous cooperation throughout the study period.

The author would like to thank all of her friends and well wishers who always inspired her during her research specially Md. Asaduzzaman and Md. Ehsanul Haq who helped her with their valuable suggestions and directions during the preparation of this thesis paper.

The author can never repay the debt of her beloved parents, sisters, brothers and all other well wishers for their inspiration, constant encouragement and sacrifice for her higher education and regret for her inability for not to mention every one by name.

Mst. Sonia Sultana

EFFECT OF AGE OF SEEDLINGS AND NUMBER OF PLANTS PER HILL ON THE GROWTH AND YIELD OF ONION

By

MST. SONIA SULTANA

ABSTRACT

An experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka during October 2014 to April 2015. There were four levels of age of seedling viz. T_1 = 30, T_2 = 40, T_3 = 50 and T_4 = 60 days old seedling, respectively. Three levels of plants per hill viz. P_1 = one, P_2 = two and P_3 = three plants/hill, respectively. The experiment was laid out in Randomized Complete Block Design with 3 replications. The age of seedling and number of plants/hill showed significantly influenced the growth, yield components and yield of onion bulb. T_3 treatment gave the maximum value for different growth and yield parameter and produced the maximum yield of bulbs of onion (8.82 t/ha). The highest yield of onion (8.45 t/ha) was produced by P_2 treatment and the lowest yield (6.92 t/ha) was at P_1 treatment. The combined effect of age of seedling and number of plants/hill demonstrated a significant variation in fresh weight of bulb (ranging from 68.25 g to 48.82 g) and yield (ranging from 5.52 to 9.40 t/ha). The highest yield was (9.40 t/ha) found at T_3P_2 treatment. The treatment T_3P_2 increased the total yield and gave the highest gross return (Tk. 4,23,000/ha) and net (Tk. 2,66,984/ha) returns with the highest profit (BCR value of 2.71) compared with the rest of the treatment combinations. From growth, yield and economic point of view, it is apparent that T_3P_2 treatment was suitable for onion cultivation.

CONTENTS

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATE

LIST OF APPENDICES

ABBREVIATIONS AND ACRONYMS

%	:	Percentage
@	:	At the Rate of
Abst.	:	Abstract
AEZ	:	Agro-Ecological Zone
Agric.	:	Agriculture
AVRDC	:	Asian Vegetables Research and Development Center
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BAU	:	Bangladesh Agricultural University
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit Cost Ration
cm.	:	Centimeter
cv.	:	Cultivar
DAT	:	Day After transplanting
et al.	:	et alii (and others)
FAO	:	Food and Agriculture Organization of the United Nations
Fig.	:	Figure
FW	:	Fresh weight
FYM	:	Farm Yard Manure
G	:	Gram
Hort.	:	Horticulture
i.e.	:	That is
J.	:	Journal

K	:	Potassium
Kg	:	Kilogram
LSD	:	Least Significant Difference
M	:	Meter
MP	:	Murate of Potash
N	:	Nitrogen
NS	:	Non-significant
^{O}C	:	Degree Celsius
P	:	Phosphorus
RCBD	:	Randomized Complete Block Design
Sci.	:	Science
Soc.	:	Society
t	:	Tonne
ton/ha	:	Ton per hectare
Tk.	:	Taka
TSP	:	Triple Super Phosphate
UK	:	United Kingdom
UNDP	:	United Nations Development Program
Viz.	:	Namely

CHAPTER I

INTRODUCTION

Onion (*Allium cepa* L.) is an important bulbous crop. It is a member of Alliaceae family (Hanlet, 1990). It belongs to the genus *Allium*. Central Asia is the primary center of its origin and the Mediterranean is the secondary center for large type onion (McCullum, 1976). The top most producer of onion in world is China, USA, Japan, India and Spain (FAO, 1993). Onion is grown throughout the world for its pungency and nutritive value. It is also considered as one of the important vegetable crops (Thomson and Kelly, 1985). It is popular salad crop and also widely used as a cooked vegetable in soups, as flavouring agent in many dishes. Among the spice crops grown in Bangladesh, onion ranks second (3, 78,000 acres) next to chilli (3, 78,000 acres) in area and first (9, 25,000 mt) in production during the year 2012-2013 (BBS, 2014).

It is a photo and thermo sensitive crop (Davies and Jones, 1944). It is widely cultivated throughout Bangladesh during winter season and its cultivation is concentrated in the greater districts of Faridpur, Pabna, Rajshahi, Jessore, Dhaka, Mymensingh, Comilla, Rangpur (BBS, 2012). It has a good demand in Bangladesh as well as in the world. In Bangladesh total area coverage 34,600 acres and production 83,500 metric ton but our demand is more than the production (BBS, 2014). Therefore, there is a gap between demand and production of onion. So, high technology and proper production technique should be needed to enhance onion production.

The average yield of onion in Bangladesh is very low (2.89 mt/acre) (BBS, 2013) as compared to the world average yield (19.45 t/ha) (FAO, 2013). It is also used in curry and also has medicinal value such as malaria, high blood pressure, senseless, insect bite and hair fall preventive measures. Onion contains protein, fat, vit-A, vit-B, vit-C, thiamine, niacin, iron and calcium. In 100 gm of raw bulb tissue, there are 50 IU of vitamin A, 0.03 g of thiamine,

0.04 g of riboflavin, 0.02 g of niacin and 9.0 g of ascorbic acid (Pruthi, 1987). The 13 outstanding characteristics of onion are associated with the pungency which is due to a volatile oil known as "Allyl-propyl-disulphide"($C_6H_{12}S_2$) (Yawalkar, 1985). Because of its importance in cookery, onion is called "queen of the kitchen" by Germans.

It grows a wide range in Bangladesh during the cool or Rabi season. Onion can be grown under a wide range of climatic condition but they succeed best in a mild climate without excessive rainfall or great extreme of heat and cold. They are not suited in an area where heavy rainfall in the lowland humid tropics. Cool condition with an adequate moisture supply is the most suitable for early growth, followed by warm, drier condition for maturation, harvesting and curing. The plants at early stage can withstand the freezing temperature. Bose *et al.* (1993) reported that 20 to 25^0C temperature was optimal for onion seed germination. For vegetative growth lower temperature and short photoperiod are required, while relatively higher temperature and long photoperiod are needed for bulb development. It requires 13 to 21^0C for vegetative growth before bulb formation and 15.5 to 25.1^0C temperature for growth and development of bulb.

Onion production is greatly influenced by agronomic practices such as, planting time, planting density, age of seedling, condition of seedling, judicious fertilization etc. Specially, age of seedling and number of plants per hill are very important for growth and production of onion.

Age of seedling is one of the important factors, which influences the growth, yield and quality of crop. Proper age of seedling can produce better yield of bulb (Singh and Chaure, 1999; Maurya *et al.*, 1997; Singh and Singh, 1974; Thomson and Kelly, 1957). As climatic factors such as atmospheric temperature, humidity and day length etc. affects the yield of onion bulbs. Planting time has an important role in physiological activities and bulb initiation. So, planting at different age of seedlings is needed to identify the suitable ages for good bulb production.

In Bangladesh, the farmers generally allow to grow single plant/hill. The number of plants/hill can increase the production of onion like a number of vegetables such as tomato, sweet potato and carrot (Tarafder, 1999; Islam, 1990; Azam, 1989). In case of carrot, planting of more than one plant/hill has been shown that two, three or four plants/hill produced significantly higher yield one plant/hill (Tarafder, 1999). Total onion yield increases, but bulb size decreases, as plant population increases (McGeary, 1985). Onions produce large bulbs when spaced widely and smaller bulbs when planted densely (Davis and Jones, 1944); however, they can push out into available space to some extent, even if planted close together. The number of onion plants/hill may be increased to take advantage of their ability to use space in the field, and at the same time reduce the space needed to produce plants in the greenhouse. But the effects of planting more than one plant/hill at different spacing of onion have not been investigated in Bangladesh.

Considering the above facts, the present study was undertaken to investigate the effect of age of seedling and number of plants/hill with the following objectives:

i. To find out the appropriate age of seedlings for higher yield and suitable bulb size;
ii. To assess the possibility of obtaining higher yield of onion through transplanting more than single plant/hill and
iii. To investigate the combined effect of different age of seedlings and number of plants/hill on the growth and yield of onion.

CHAPTER II

REVIEW OF LITERATURE

Onion is one of the most important spice crops of the world. The production of onion is influenced by many factors, such as age of the seedling and number of plants per hill are closely related to growth and yield of onion.

A number of research works on age of seedling and number of plants/hill in onion had been conducted in different parts of the world. The present study has been undertaken to investigate the effect of age of seedling and number of plants/hill on growth and yield of onion. However, the research findings related to the present study have been reviewed here to explain and interpreted the results of the present investigation.

2.2 Effect of seedling age on growth and yield of onion

Rahman *et al.* (2004) concluded that early planting favourably influenced plant height, number of leaves per plant, dry weights of leaves, bulbs and roots, total dry matter (TDM), leaf area index (LAI), crop growth rate (CGR), bulb diameter, individual bulb weight as well as yield. With the delay in planting time starting from November 07, the yield was chronologically reduced in later plantings. The highest bulb yield (2.67 t ha^{-1}) was recorded from November 07 planting and the minimum (0.92 t ha^{-1}) from December 22.

Bhonde *et al.* (2001) carried out an experiment with onion on age of seedling (7, 8 and 9 weeks) and date of harvesting (110, 125 and 140 days after transplanting) on yield and quality during late kharif season. Agrifound Red Light was investigated during 1997/98, and 1999/2000 at Nasik Maharashtra, India. Data were recorded for plant highest, bulb development, bolting doubling, bulb yield, bulb weight, dry matter percentage and total soluble solids. The use of 8 weeks old seedlings and harvesting at 125 days after transplanting gave the best yield and quality and highest net returns compared with the other treatments.

Singh and chaure (1999) conducted a field trial in 1989-92 to observe at the age of seedling and nitrogen levels on the yield of onion. Seedlings of 5, 6 and 7 weeks old were used. They found that optimum seedling age in terms of leaf length, number of leaves per plant, bolting percentage, bulb weight and bulb yield was 6 weeks old.

Ha *et al*. (1998) conducted an experiment with sowing date and age of seedling of onion. They worked three age of seedling. Seedling quality improved as seedling age increased from 35 to 55 days. It was observed that, seedling establishment was enhanced by young plug seedlings, higher rates of bolting and doubling of bulbs occurred with early sowing and old young seedlings.

Sharma (1998) conducted an experiment with seedling age and nitrogen levels of onion. He used 4, 5, 6 and 7 weeks old seedlings. Plant height, number of leaves per plant and mean bulb yield increased significantly as seedling age at transplanting increased up to 6 weeks old.

Maurya *et al*. (1997) conducted an experiment to observe the effect on yield of onion with seedling age. They planted 30, 40, 50, 60, 70, 80 or 90 days old seedlings, and found that 60 days old seedlings gave the highest bulb yield of onion 282.22 q/ha followed those planted at 50 days 238.89 q/ha.

Liu *et al.* (1996) conducted an experiment with plant size and seedling age of onion. Seedlings were raised to ages of 35, 45, 55 and 65 days in 3 plant size. All seedlings grew well. They found that 55 and 65 days old seedlings were larger in size at transplanting and produced higher yields and matured earlier than 45 days old seedlings.

Oladiran and Sangodele (1996) conducted an experiment to observe the effect of cultivar and age of seedling for bulb yield of onion in Nigeria. They used onion seedlings from August sowing of cultivars Ex. Gaya nawa, Ex. Dala, D77 and Composite 4 were transplanted in the field at the ages of 4, 6 and 8 weeks, except Composite 4 other cultivar produced widest bulb from

transplanted at 6 weeks old seedlings. Composite 4 gave better results at 4 weeks old seedlings.

Herison *et al.* (1993) reported that three onion (*Allium cepa* L.) cultivar transplants were grown in the greenhouse in 200-cell plastic trays with one, two, or three plants per cell; at 75, 150, or 225 ppm N; and for 8, 10, or 12 weeks. Increasing the number of plants per cell resulted in smaller seedlings at transplanting and reduced time to maturity in the field by 1 week. Two and three plants per cell yielded more bulbs greater than 76 mm in diameter, but one plant per cell had the highest percentage of bulbs greater than 102 mm in diameter. Older seedlings and higher N applications produced larger plants at transplant and larger bulbs at harvest. Increasing N applications reduced maturation time slightly. Bulb fresh weight at harvest and yield of bulbs greater than 76 mm in diameter were highest with 10 and 12 week old transplants and at 150 and 225 ppm N.

Mohanty *et al.* (1990) carried out an experiment with onion on time of transplanting (20 November, 20 December, 4 January or 19 January in 1986–87 and 1987/88) and age of seedling (6, 8, and 10 weeks old seedlings) on yield of onion. The bulbs were harvested 123 days after transplanting. Average yield, bulb diameter and bulb weight were highest (291.14–304.60 q/ha, 6.60–6.66 cm and 117.77–126.54 g respectively0 for the 20 Nov. and 5 Dec. plantings in both years, and decreased markedly with later planting dates. The maximum increase in yield of the early over the late plantings was 76.75 %. In both years, yield and bulb diameter increased with the age of seedlings over 6-week old seedlings were 95.75 % and 52.94 % respectively.

Park and Lee (1989) reported that early planted plants produced larger bulbs than the late planted plants.

Vaccani and Patel (1989) conducted a field trial to identify the response of seedling age of yield of onion. They worked with 4, 5, 6, 7,8, 9 and 10 weeks old seedling and observed that, the yield increased with seedling age from

257.7 q/ha with 4 weeks old seedling to 462.3 q/ha with 7 weeks old seedlings, but then decreased gradually to 325.3 q/ha with 10 weeks old seedlings.

Rahim and Forhad (1988) reported that the plants that produced smaller bulb may be explained by the fact that the plants did not receive a long cool growing period, which was essential for proper development of bulbs.

Vaccani and Patel (1988) conducted an experiment with seedling age at transplanting of onion. Seeds of the cultivar Pusa Red were sown 4, 5, 6, 7, 8, 9 or 10 week old seedlings were transplanted in the field at 15 cm × 10 cm. the crop received NPK fertilizer and was harvested. Data are tabulated on the number of leaves/plant, plant height, bulb diameter, bulb weight, and yield. The bulb yield was height (462.3 q/ha) from transplanting 7 weeks old seedlings and lowest (257.7 q/ha) from transplanting 4 weeks old seedlings.

Rahman and Talukder (1986) observed that the largest bulb size from the early planting contributed the highest yield.

Rahim *et al*. (1984) reported that height of garlic plant was decreased as the planting was delayed.

Khan (1981) concluded that the linear increase in LAIs with time was due to increased number of leaves and vigorous growth.

Rahman (1981) observed that early planting produced higher number of leaves per plant and decreased gradually with the late planting.

Prasad *et al.* (1978) observed that the initial slow rate of development of LAI was for poor vegetative growth and low temperature.

In Bangladesh, Ahmad (1976) suggested that, 30 to 35 days old seedling should be transplanted for the production of onion bulb.

In Bangladesh, Rashid (1976) reported that, 40 to 45 days old seedling should be transplanted for the production of onion bulb in winter season.

In a study at Nainital, India, Singh and Singh (1974) observed that, 5 to 6 weeks old seedlings were better in 4 to 7 weeks old seedlings.

As regards to the investigation seedling age on the production of onion at China, Herklots (1972) stated that, onion seedlings should be transplanted to the field when they are large enough to handle.

In India, Verma *et al.* (1971) transplanted seedling at the age of 4, 6, 8 and 8 and 10 weeks and observed that 8 weeks old seedlings gave the highest yield of bulb.

Yu and Ts (1966) planted onion seedling ranging in age from 25 to 60 day. They observed quickest growth, earliest maturity and largest bulb in the seedling aged 30 days in China.

Jones and Mann (1963) found that smaller bulbs and lower yield was obtained from late planting which did not receive a long cool growing period which was essential for proper development of vegetative growth for garlic.

Patil *et al*. (1958) observed that when the transplanting age of Nasi Red onion was increased by one-week from 7 to 14 weeks, there was progressive increase in yield in two out of three experimental years at Puna. They suggested that 56 to 63 days old seedling should be transplanted.

Thompson and Kelly (1957) suggested that 42 to 70 days old seedlings should be planted.

Watson (1947) reported that the subsequent reduction of LAI after attaining the maximum was due to the senescence of older leaves. Higher productivity of a crop depends on the persistence of high LAI.

2.2 Effects of number of plants/hill

Optimum number of plants/hill is one of the most important and uncontroversial factors for maximizing the yield of crop. The results of many researchers relating to number of plants/hill of underground crops including onion are reviewed. Like other underground crops more than one plant/ hill can increase the yield of onion. The available information relating to plants/hill of onion are reviewed below.

Halder (2001) conducted an experiment on the effect of plant spacing, number of plants per hill and mulching on the growth and yield of carrot under Bangladesh (BAU) condition. She found that two or three plants per hill produced significantly higher than one plant per hill.

Tarafder (1999) studied the effect of plant spacing and number of plants per hill on the growth and yield of carrot under Bangladesh (BAU) condition. He found that two, three or four plants per hill produced significantly higher yield than one plant per hill.

Herison *et al*. (1993) conducted an experiment at three onion cultivars sweet Sandwich, Vega and Yula were sown in the green house in 200-cell plastic trays and thinned to one, two or three seedlings/cell. Seedlings were transplanted in to the field 12 weeks after sowing, without separating individual plants from multi plant cells. Two and three plants/cell yielded a higher percentage of bulbs 76 mm in diameter, however one plant/cell yielded more bulbs of 102 mm in diameter.

Frost and Kretechman (1988) worked on a trial with two varieties “Heing 2653” and “Heing 722” of tomato grown at fore plant populations (21,530; 28,700; 43,050 and 57,400 plants/ha) in both single and twin rows, found that as population pressure increased, number of ripe fruits/plant, ripe fruit size and clusters/plant decreased.

In determining the effect of optimum number of tomato plants per hill, Rosell *et al.* (1987) observed that the total yield was maximum (28.6 t/ha) with three plants per hill (37,500 plants per hill) with a spacing of 140 cm and 60 cm, respectively between and within the row.

Rahman, (2008)conducted an field experiment was carried out at the Sher-e-Bangla Agricultural University Farm, Dhaka, to study the effect of nitrogen and number of plants per hill on growth and yield of onion (*Allium cepa* L.). He found that three plants per hill with 180 kg N/ha can be used to obtain higher growth as well as higher yield.

Siddique and Rabbani (1987) studied the effects of length of cuttings, part of vine inserted into the soil at planting and number of vines planted per hill on the yield of sweet potato. They observed that the number of tuberous roots per hill and yield were increased when two vine cuttings were planted per hill.

Saladaga and Rodolfo (1987) stated that generally no significant differences in agronomic characters and yield components of sweet potato were observed using either the traditional method or the recommended practice planting. Varying the number of cuttings per hill significantly influenced only the fresh vine weight of Kaimay BNAS-51 and Summer Big Yellow sweet potato verities. Plants that developed from one cutting per hill produced heavier herbage than other treatments. Root yield was likewise not markedly affected by the number of cuttings per hill although the varieties significantly differed in this parameter. Among the varieties Kaimay obtained the highest value in yield and nearly all yield components.

Dragland (1986) carried out an experiment in Norway seeding of the carrot cv. Nantes Duke sown in may were thinned out to give densities of 45, 70 or 90 plants/m^2 in beds of 2, 3, 4 or 5 rows between path ways (wheel tracks) 150 cm apart, Centre to centre and 28 cm wide. At the first harvest on l^{st} September the highest saleable yield (29 t/ha) was achieved with a density of 70 plants/m^2

distributed in 4 rows. At harvest on 10 October, a density of 90 plants/m^2 in 4 or 5 rows gave the highest yield (42 t/ha).

Nassar (1986) reported that two seedlings planted per hill contributed maximum yield of tomato.

Hiron (1983) found that, the yield of bulbs greater than 40 mm diameter reaches a maximum of 45-55 ton/ha. When modules containing five to six seedlings are transplanted at ten modules per m^2.In these conditions 60-70% of the bulbs are greater than 60 mm in diameter. Using more seedlings per module, or planting modules at a higher density, reduced mean bulb size.

Vik (1974) carried out an experiment in Norway and showed that satisfactory bulb crops were produced when groups of three to seven seedlings were raised in small pots and transplanted as a cluster. During bulbing the plants pushed each other apart and the resulting bulbs were not misshapen.

Mandal *et al*. (1973) conducted an experiment at Trivandrum in India used non branched (H-165) and branched (H-97) types of tapioca (*Manihot esculenta*) to study the effect of plant density, fertile level and shoot number on tuber yield and quality of tapioca hybrids and found that two plants per hill gave a better yield than that of one plant per hill. They recommended spacing of 75 cm×75 cm, with two plants per hill and 90 cm×90 cm with one plant per hill for types H-165 and h-97, respectively.

CHAPTER III

MATERIALS AND METHODS

In this section the materials and methods have been presented with a brief description of location of the experimental site, soil, climate, planting materials etc. The details of research procedure are described under.

3.1 Description of the experimental site

3.1.1 Location

The present research work was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka during October 2014 to April 2015 to study the effect of age of seedlings and number of plants per hill on the growth and yield of onion (*Allium cepa* L.). The location of the site 90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level (Anon, 1989). Location of the experimental site presented in Appendix I.

3.1.2 Soil

Soil of the study site was salty clay loam in texture belonging to series. The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with PH 5.8-6.5, ECE-25.28 (Haider *et al*., 1991). The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka and have been presented in Appendix II.

3.1.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by 3 distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October (Edris *et al*., 1979). Details of the

metrological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix III.

3.2 Planting materials

The seeds of onion cv. BARI Piaz-1 variety was collected from Bangladesh Agricultural Research Institute (BARI), Gazipur. The variety produces plants of 25 to 30 cm tall with 7 to 10 leaves per plant. The diameter of bulb is 4 to 5 cm. The bulbs are highly pungent with pinkish red skin and the yield of bulb is about 8 to 10 t/ha.

3.3 Experimental details

3.3.1 Treatments

There are two factors named as factor-A (age of seedlings) and Factor-B (number of plant/hill).

Factors-A: 4 levels

i. T_1 = 30 days old seedlings
ii. T_2 = 40 days old seedlings
iii. T_3 = 50 days old seedlings
iv. T_4 = 60 days old seedlings

Factors-B: 3 levels

i. P_1 = 1 plant/hill
ii. P_2 = 2 plants/hill
iii. P_3 = 3 plants/hill

There were 12 (4 × 3) treatments combination such as T_1P_1, T_1P_2, T_1P_3, T_2P_1, T_2P_2, T_2P_3, T_3P_1, T_3P_2, T_3P_3, T_4P_1, T_4P_2 and T_4P_3.

3.3.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with 12 treatment combinations having three replications. First of all, the entire experimental plot was divided into three blocks, each of which was then divided into 36 unit plots. The treatment combinations was assigned randomly to the unit plots of one block. The size of unit plot was 1m × 1m and number of replication 3. Two adjacent unit plots and blocks was separated by 50 cm and 50 cm respectively.

3.4 Raising of seedlings

High, well drained and sunny place was selected for seedbed preparation. The land was ploughed finely and drying for 10 to 15 days. Weeds were removed finely and finally. The soil was made into friable, loses and brought into fine tilth, other stubbles were removed. Onion seedlings were raised in two seedbeds situated on a relatively high land adjacent to the Horticultural Farm Office. The size of each seedbed was 3m × 1m with height of about 10 cm was made. Seeds were soaked in water for one night and then kept in a piece of cloth for sprouting. After sprouting the seeds were sown in the seedbed at a depth of 0.5 cm on 15 October, 2014. Curator @ 6 kg/ha was dusted over the seedbed to protect the germination seeds from ants. To shade were given. The germination was complete within 7 days after sowing. Light irrigation with a watering can was given whenever necessary. Weeding was done as and when required.

3.5 Cultivation procedure

3.5.1 Land preparation

The plot selected for the experiment was opened in the first week of November, 2014 with a power tiller and was exposed to the sun for a week, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. The weeds, crops residues and stables were removed from the field. The basal dose of manures and fertilizers was applied at the finally ploughing. According to design and layout the plots was prepared. The soil was treated by Sevin 50 WP @ 5kg/ha to protect the young plants from the attack of mole cricket, ants and cutworm.

3.5.2 Fertilizers and manure application

Farmyard manure (FYM), Urea, TPS, MoP and Gypsum were applied @ 15 ton, 260, 200, 160 and 80 kg/ha, respectively (BARI krishi projukti hatboi,

2005). The FYM was applied after opening the land. The total amount of TSP, ½ MP and full gypsum were applied at the final land preparation. Total urea and ½ MP were applied in two installments. The first instalments were applied at thirty days after transplanting; second installments were applied 45 days after transplanting as top dressing. The fertilizer was thoroughly mixed with the soil.

3.5.3 Transplanting of seedlings

30, 40, 50 and 60 days old healthy and disease free uniform seedlings were uprooted from the seedbed and transplanted in the main field on 15 November, 2014; 25 November, 2014; 5 December, 2014 and 15 December, 2014 at 20 cm × 10 cm spacing.

Uprooting of seedlings was done in the afternoon very carefully so that seedlings were not injured. Light watering was given just after transplanting the seedlings in the experimental plots. Some seedlings were also transplanting around the experimental plot for gap filling.

3.6 Intercultural operations

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the plants. So the crop was always kept under careful observation.

3.6.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after transplanting the seedlings in every alternate day in the evening. Further irrigation was done when needed. Stagnant water was effectively drained out at the time of heavy rains.

3.6.2 Gap filling

First gap filling was done for all of the plots at 10 days after transplanting by planting same aged and same sources seedlings. Damaged/ dead seedlings were removed.

3.6.3 Weeding

Three weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after transplanting (DAT), 2nd and 3rd weeding was done at 35 and 55 DAT.

3.6.4 Plant protection

Preventive measure was taken against soil borne insects. Furadan 3G @ 20kg/ha was applied for the prevention of cutworm. After pesticide application no insect infestation was found in the field. Few days after transplanting some plants were attacked by purple blotch disease caused by *Alternaria porri*. It was controlled by spraying Ruvral 50 WP @ 2g/ L of water at 7 days interval.

.3.6.5 Removal of scape

The flower stalk was removed whenever appeared in plants. This was done daily by keen inspection.

Plate 1. After removing flower stalk from plants

3.7 Harvest

When the leaves became collapse and leaves became dry, the crop was harvested at different dates viz. 5 March, 2015; 15 March, 2015; 25 March, 2015 and 5 April, 2015. Onions were lifted with the help of hand and care was taken so that no bulb was injured during lifting. The tops were removed by cutting of the pseudostem keeping 2.5 cm with the bulb.

Plate 2. During harvesting of T_1P_1 treatment

3.8 Data collection

3.8.1 Plant height

The heights of pre-selected ten plants were measured with a meter scale from the ground level to the top of the tallest leaf after 20 days of transplanting and then 10 days interval up to 40 days of transplanting and the mean height was expressed in cm.

T_1P_1 treatment **T_1P_2 treatment**

Plate 3. Comparison of plant height parameter between T_1P_1 and T_1P_2 treatment

3.8.2 Number of leaves per plant

Total number of leaves per 10 plants was counted after 20 days after transplanting and then 10 days interval up to 50 days of transplanting and the average number of leaves per plant was recorded.

3.8.3 Leaf length

The heights of pre-selected ten plants leaves were measured with a meter scale from the ground level to the top of the tallest leaf and the mean height was expressed in cm.

3.8.4 Plant base diameter

Diameter of plant base measured at the middle portion of 10 selected plants from each plot with slide callipers and there average was taken in mm as the diameter of plant base.

3.8.5 Dry matter content of leaf

100 g leaf was collected from ten plants randomly in each unit plot sliced finely. Then sliced onion leaf was dried in the dun kept in oven at 72°C for drying. It took 72 hrs. The weight of dry matter was converted into percentage of dry matter content of leaf per plant using the following formula:

$$\text{Dry matter content (\%)of leaf} = \frac{Dry\ weight\ of\ the\ sample}{Fresh\ weight\ of\ the\ sample} \times 100$$

3.8.6 Fresh weight of leaves

Determined from harvested fresh leaf of 10 selected plants were weighted and their average as the fresh leaf weight per plant.

3.8.7 Foliage diameter

Diameter of foliage measured at the middle portion of 10 selected plants from each plot with slide callipers and there average was taken in cm as the diameter of foliage.

3.8.8 Length of bulb

The length of bulb was measured with a scale from the neck of the bulb of the bottom of 10 selected bulbs from each plot and there average was taken in cm as the length of bulb.

3.8.9 Diameter of bulb

Diameter of bulb measured at the middle portion of 10 selected bulbs from each plot with slide callipers and there average was taken in cm as the diameter of bulb.

3.8.10 Fresh bulb weight

Determined from harvested fresh bulb of 10 selected plants were weighted and their average was taken as the fresh bulb weight per plant.

3.8.11 Bulb dry matter

100 g bulbs were collected from ten selected plants randomly in each unit plot sliced finely. Then sliced bulb was dried in the dun kept in oven at 72°C for drying. It took 72 hrs. The weight of dry matter was converted into percentage of dry matter content of bulb per plant using the following formula:

$$Bulb\ dry\ matter\ (\%) = \frac{Dry\ weight\ of\ the\ sample}{Fresh\ weight\ of\ the\ sample} \times 100$$

3.8.12 Yield of bulb per plot and per hectare

An electric balance was used to take the weight of bulb per plot. It was measured by totalling the bulb yield of each unit plot separately harvest and was recorded in gram (g).

Yield per hectare was measured by following formula:

$$Bulb\ yield\ per\ hectare\ (ton) = \frac{Bulb\ yield\ per\ plot\ (kg) \times 10{,}000}{Area\ of\ plot\ in\ square\ meter\ \times 1{,}000}$$

Bulb of T_3P_2 treatment

Plate 4. Bulb of two plants/hill at 50 days old seedlings

T_2P_1 treatment **T_2P_2 treatment**

T_2P_3 treatment

Plate 11. Comparison among one bulb, two bulb and three bulb at T_2 treatment

3.9 Statistical analysis

The data obtained for different characteristics were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characteristics were calculated and analysis of variance was performed. The significance of the difference among the treatment means was estimated by the Least Significant Different (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

3.10 Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of nutrient sources and mulching. All input cost were considered in computing the cost of production. The market price of spike, bulb and bulblet was considered for estimating the return. The benefit cost ratio (BCR) was calculated as follows:

$$Benefit\ cost\ ratio = \frac{Gross\ return\ per\ hectare\ (Tk.)}{Total\ cost\ of\ production\ per\ hectare\ (Tk.)}$$

CHAPTER IV

RESULTS AND DISCUSSIONS

The experiment was conducted to find out the effect of age of seedlings and number of plants per hill on the growth and yield of onion. The results obtained from the study have been presented, discussed and compared in this chapter through tables, figures and appendices. The analyses of variance of data in respect of all the parameters have been shown in Appendix IV-IX. The results have been presented and discussed with the help of table and graphs and possible interpretations given under the following sub headings.

4.1 Plant height

Plant height is an important parameter which reflects the vegetative growth of plant. The plant height was significantly influenced by seedlings of different age (Figure 1 and Appendix IV). It was recorded at 20, 30, 40 and 50 days after transplanting, that is at 10 days interval. Among the treatments it was found that plant height was gradually increased with the advancement of time. Plant height was gradually increased upto 40 DAT. The maximum plant height (47.97 cm) was observed from T_3 (50 days old seedlings) treatment at 40 DAT and followed by (41.41 cm) T_2 (40 days old seedlings) treatment, while the minimum (36.03 cm) was observed from T_4 (60 days old seedlings) treatment. This might be due to the fact that 50 days old seedlings possibly received favorable condition for quickest growth than those of other age of seedlings. This result is in agreement with the result obtained by Ha *et al.* (1998), they reported that seedling quality improved as seedling age increased from 35 to 55 days. Sharma (1998) also reported that the highest plant height of onion was observed from 6 weeks old of seedling age.

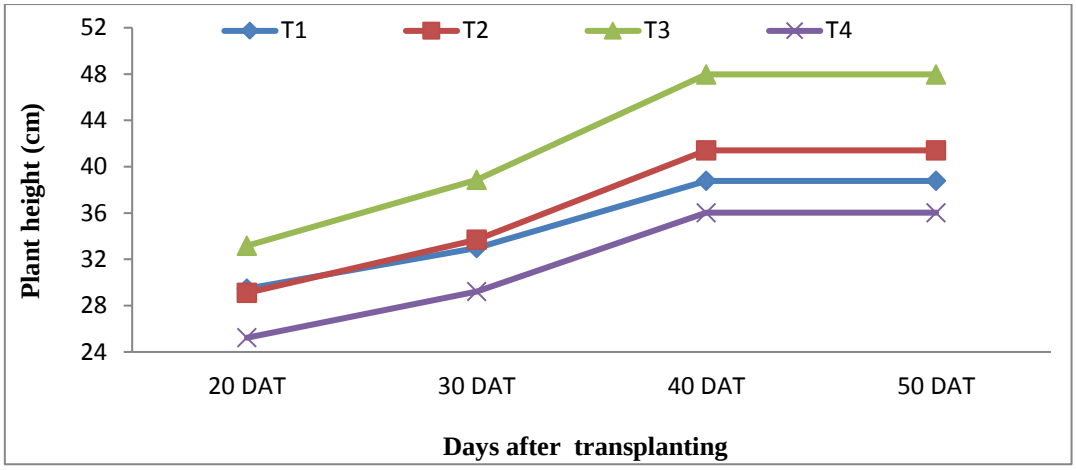


Figure 2. Effect of seedling age on plant height (cm) of onion

(LSD value = 0.41, 0.54, 0.43 and 0.62 at 20, 30, 40 and 50 DAT, respectively) Note: T_1 = 30 days old seedling, T_2 = 40 days old seedling, T_3 = 50 days old seedling, T_4 = 60 days old seedling

The plant height was observed significantly influenced by no. of plants/hill. The maximum plant height (43.88 cm) was recorded from P_1 (one plant/hill) treatment at 40 DAT, while the minimum (38.50 cm) was observed from P_3 (three plants/hill) treatment at the same growth stage (Figure 2 and Appendix IV). The shortest plant heights at all dates of observations were found when three plants/hill were planted. The variation in plant height as influenced by number of plant/hill was perhaps due to proper utilization nutrients, moisture and light. This result is agreed with the findings of Rahman (2004).

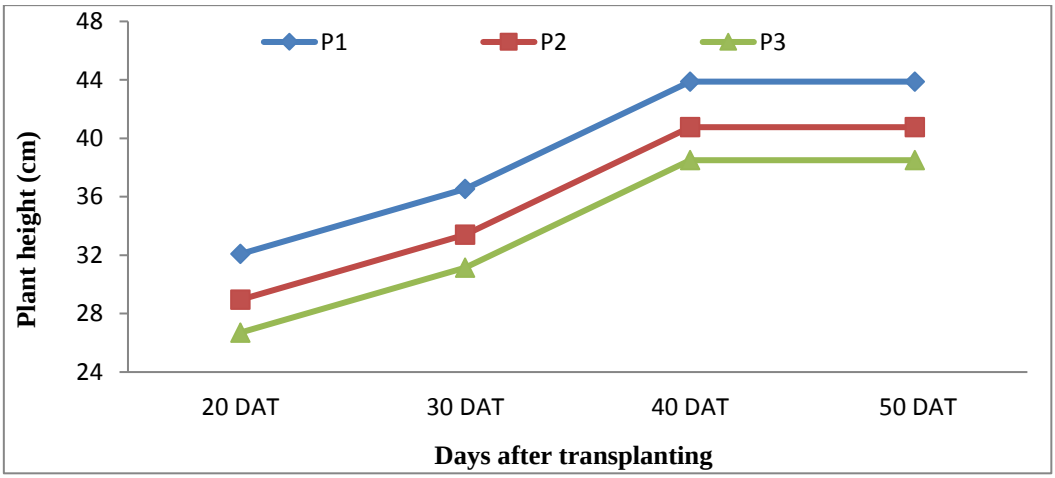


Figure 3. Effect of number of plants per hill on plant height (cm) of onion

(LSD value = 0.35, 0.47, 0.37 and 0.54 at 20, 30, 40 and 50 DAT, respectively) Note: P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

The combined effect of age of seedlings and number of plants/hill was found statistically significant on all dates of observation (Table 1 and Appendix IV). The maximum plant height (49.30 cm) was measured from T_3P_1 (50 days old seedlings with one plant/hill) treatment at 40 DAT followed (48.30 cm) by T_3P_2 (50 days old seedlings with two plants/hill) treatment at the same growth stage. The lowest plant height (33.90 cm) was observed from T_4P_3 (60 days old seedlings with three plants/hill) treatment. This might be due to the fact that environmental conditions for vegetative growth were favorable for older seedlings for completing vegetative growth.

Table 1. Combined effect of seedling age and number of plants per hill on plant height of onion at different days after transplanting (DAT)

Treatments	Plant height (cm) at			
	20 DAT	30 DAT	40 DAT	50 DAT
T_1P_1	32.20 c	35.70 e	41.50 e	41.50 e
T_1P_2	30.10 e	33.60 f	39.40 g	39.40 g
T_1P_3	26.10 g	29.60 i	35.40 i	35.40 i
T_2P_1	33.40 b	38.00 c	45.70 d	45.70 d
T_2P_2	27.80 f	32.40 g	40.13 f	40.13 f
T_2P_3	26.10 g	30.70 h	38.40 h	38.40 h
T_3P_1	34.50 a	40.20 a	49.30 a	49.30 a
T_3P_2	33.50 b	39.20 b	48.30 b	48.30 b
T_3P_3	31.50 d	37.20 d	46.30 c	46.30 c
T_4P_1	28.20 f	32.20 g	39.00 g	39.00 g
T_4P_2	24.40 h	28.40 j	35.20 i	35.20 i
T_4P_3	23.10 i	27.10 k	33.90 j	33.90 j
$LSD_{(0.05)}$	0.41	0.54	0.43	0.43
CV (%)	6.78	6.10	8.61	8.61

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: T_1 = 30 days old seedling, T_2 = 40 days old seedling, T_3 = 50 days old seedling, T_4 = 60 days old seedling and P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

4.2 Number of leaves

Good foliage indicates higher growth, development and productivity of plant. In the present study the number of leaves per plant was found to be significantly influenced by the age of seedlings (Figure 3 and Appendix V). From the figure it was observed that the number of leaves per plant increased

from 20 DAT to 40 DAT. The maximum number of leaves (11.33) per plant of onion was observed from T_3 (50 days old seedlings) treatment at 40 DAT, while the minimum number of leaves (8.53) was observed from T_4 (60 days old seedlings) treatment at the same growth stage. Similar trend was obtained by Sharma (1998), who reported that plant height, number of leaves per plant and bulb yield increased significantly as seedling age at transplanting increased up to 6 weeks old.

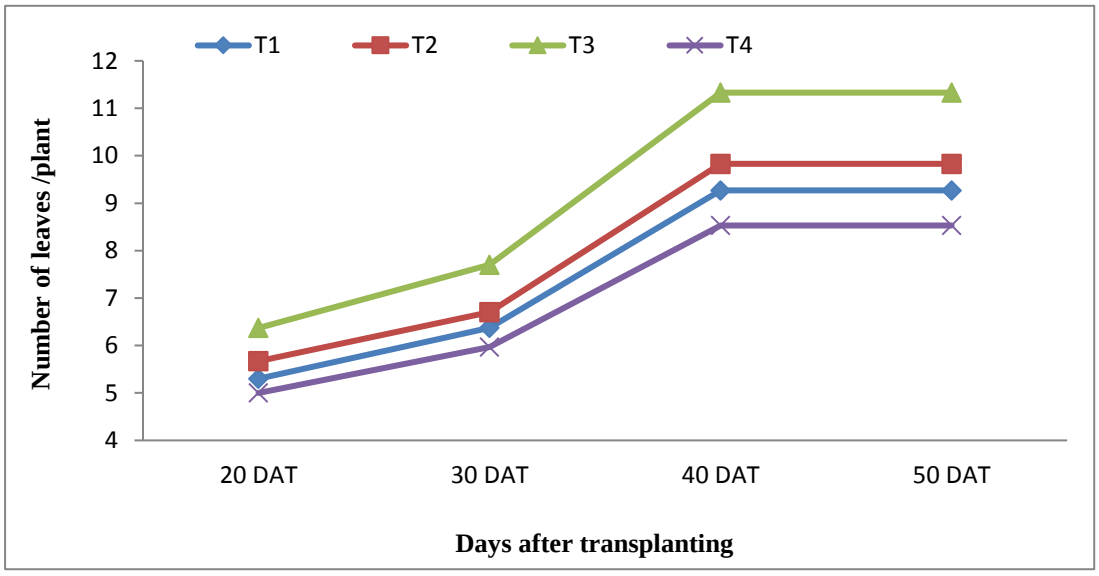


Figure 4. Effect of seedling age on number of leaves per plant of onion

(LSD value = 0.29, 0.51, 0.38 and 0.43 at 20, 30, 40 and 50 DAT, respectively) Note: T_1 = 30 days old seedling, T_2 = 40 days old seedling, T_3 = 50 days old seedling, T_4 = 60 days old seedling

The results showed highly significant effect of number of plant/hill treatment on the number of leaves per plant from 20 DAT to 40 DAT (Figure 4 and Appendix V). At 40 DAT the maximum number of leaves (11.43) was recorded from P_2 (two plants/hill) treatment, while the minimum number of leaves (8.20) per plant of onion was found from P_3 (three plants/ hill) treatment. It was observed that number of leaves per plant was higher in plants with two plants/hill and lower in three plants/hill. It was probably due to reduced inter plant competition for access to nutrient, moisture and other resources. This is in agreement with the findings of Maurya *et al.* (1997).

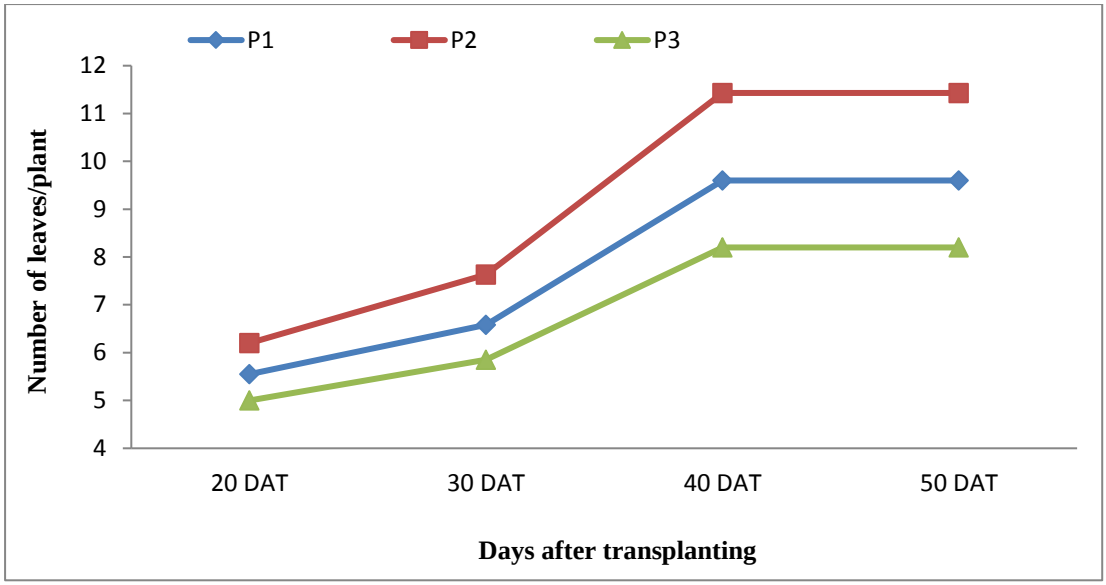


Figure 5. Effect of number of plants per hill on number of leaves per plant of onion (LSD value = 0.25, 0.45, 0.33 and 0.37 at 20, 30, 40 and 50 DAT, respectively) Note: P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

The combined effect of age of seedlings and number of plants/hill was also found to be statistically significant in this respect (Table 2 and Appendix V). At 40 DAT of onion, the maximum number of leaves (12.90) was recorded from T_3P_2 (50 days old seedlings with two plants/hill) treatment and followed (11.70) by T_2P_1 (40 days old seedlings with one plant/hill) treatment at the same growth stage. On the other hand, the minimum number of leaves (6.90) was observed from T_4P_3 (60 days old seedlings with three plants/hill) treatment at 40 DAT of onion. Younger onion seedlings received relatively optimum temperature and longer day, which increased the number of leaves to store maximum amount of food materials. This is in agreement with the statement of Mohanty *et al.* (1990).

Table 2. Combined effect of seedling age and number of plants/hill on number of leaves per plant of onion at different days after transplanting (DAT)

Treatments	Number of leaves per plant at			
	20 DAT	30 DAT	40 DAT	50 DAT
T_1P_1	5.50 de	6.80 cd	10.80 c	10.80 c
T_1P_2	5.10 f	6.30 d-f	9.50 e	9.50 e
T_1P_3	5.30 ef	6.00 ef	7.50 g	7.50 g
T_2P_1	6.30 b	7.70 b	11.70 b	11.70 b
T_2P_2	5.40 e	6.60 cd	9.80 e	9.80 e
T_2P_3	5.30 ef	5.80 f	8.00 f	8.00 f
T_3P_1	6.00 c	7.00 c	10.70 cd	10.70 cd
T_3P_2	7.60 a	9.40 a	12.90 a	12.90 a
T_3P_3	5.50 de	6.70 cd	10.40 cd	10.40 cd
T_4P_1	5.40 e	6.60 cd	10.30 d	10.30 d
T_4P_2	5.70 d	6.40 de	8.40 f	8.40 f
T_4P_3	3.90 g	4.90 g	6.90 h	6.90 h
$LSD_{(0.05)}$	0.29	0.51	0.43	0.43
CV (%)	6.09	7.84	9.70	9.70

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: T_1 = 30 days old seedling, T_2 = 40 days old seedling, T_3 = 50 days old seedling, T_4 = 60 days old seedling and P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

4.3 Leaf length

In the present study, the length of leaf was significantly influenced by the different age of seedling of onion (Table 3 and Appendix VI). The largest leaf (34.06 cm) was recorded from T_3 (50 days old seedling) treatment, which was closely followed by (24.64 cm) T_1 (30 days old seedling) treatment. In comparison, the shortest leaf (22.60 cm) was observed in T_4 (60 days old seedling) treatment. Similar result was obtained for onion in agreement with Singh and Chaure (1999).

The variation due to main effect of number of plants/hill was found significant influence in respect of leaf length of onion (Table 4 and Appendix VI). The largest leaf (27.93 cm) was recorded from P_1 (one plant/hill) treatment and followed by (25.91 cm) P_2 (two plants/hill) treatment. On the other hand, the shortest leaf (25.14 cm) was observed in P_3 (three plants/hill) treatment.

The combined effect of age of seedlings and number of plants/hill was found to be statistically significant in this respect (Table 5 and Appendix VI). The largest leaf (35.78 cm) was recorded from T_3P_1 (50 days old seedlings with one plant/hill) treatment, which was closely followed by (33.27 cm) T_3P_2 (50 days old seedlings with two plants/hill) treatment. On the other hand, the shortest leaf (19.48 cm) was observed in T_4P_2 (60 days old seedlings with two plants/hill) treatment. T_3P_1 (50 Days old seedlings with one plant/hill) treatment received more nutrients under less inter plant competition which ultimately promoted the vegetative growth with maximum length of leaves.

4.4 Plant base diameter

Seedling of different age showed significant influence on plant base diameter of onion (Table 3 and Appendix VI). The largest plant base diameter (0.90 mm) was recorded from T_3 (50 days old seedling) treatment at harvesting stage, which was followed by (0.45 mm) T_2 (40 days old seedling) treatment. In comparison, the smallest plant base diameter (0.27 mm) was observed from T_4 (60 days old seedling) treatment. This might be due to 50 days old seedling were larger in size at transplanting period and quickest growth ultimately produce higher plant base diameter. Similar result was reported by Patil *et al.* (1958).

Different number of plants/hill showed significant influence on plant base diameter of onion (Table 4 and Appendix VI). The largest plant base diameter (0.66 mm) was recorded from P_1 (one plant/hill) treatment, which was closely followed by (0.50 mm) P_2 (two plants/hill) treatment. In comparison, the smallest plant base diameter (0.38 mm) was observed in P_3 (three plants/hill) treatment. It had been showed that the increase in diameter of plant base was reported when one seedling was transplanted per hill. Similar results were obtained of Herison *et al.* (1993).

Combined effect of seedling age and number of plants/hill had significant influence on plant base diameter of onion (Table 5 and Appendix VI). The longest plant base diameter (1.05 mm) was recorded from T_3P_1 (50 days old seedlings with one plant/hill) treatment and followed by T_3P_2 (50 days old seedlings with two plants/hill) treatment (0.95 mm). On the other hand, the shortest plant base diameter (0.15 mm) was observed in T_4P_3 (60 days old seedlings with three plants/hill)) treatment.

4.5 Fresh weight of leaves

The fresh weight of leaves per plant is an important yield contributing factor of onion plant. Seedling of different age showed significant influence on fresh weight of leaves of onion (Table 3 and Appendix VI). The maximum fresh weight of leaf (25.00 g) was recorded from T_3 (50 days old seedling) treatment and followed by (22.82 g) T_2 (40 days old seedling) treatment. In comparison, the minimum fresh weight of leaf (15.50 g) was observed in T_4 (60 days old seedling) treatment. The increased fresh weight of leaves per plant was higher probably transplanting optimum old seedlings due to quicker establishment and favorable condition available by the plants for vegetative growth.

Different number of plants per hill showed significant influence on fresh weight of leaves of onion (Table 4 and Appendix VI). The maximum fresh weight of leaves (23.43 g) was recorded from P_1 (one plant/hill) treatment, which was closely followed by (21.62 g) P_2 (two plants/hill) treatment. In comparison, the minimum fresh weight of leaves (16.20 g) was observed in P_3 (three plants/hill) treatment. The decreasing trend of fresh weight of leaves with the increase in number of plants/hill might be due to overcrowding of plants/hill, facing high inter plant competition for light, nutrients,

water and air. These findings are in agreement with the result of Rahman (2004).

The significant combined effect between age of seedling and number of plants/hill was observed on fresh weight of leaves of onion (Table 5 and Appendix VI). The highest fresh weight of leaves (29.33 g) was recorded from T_3P_1 (50 days old seedlings with one plant/hill) treatment and followed by T_3P_2 (50 days old seedlings with two plants/hill) treatment (27.33 g). On the other hand, the lowest fresh weight of leaves (14.13 g) was observed in T_4P_3 (60 days old seedlings with three plants/hill) treatment.

Table 3. Effect of seedling age on leaf length, plant base diameter, fresh weight of leaves, foliage diameter and dry matter content of leaf of onion

Treatment	Leaf length (cm)	Plant base diameter (mm)	Fresh weight of leaves (g)	Foliage diameter (cm)	Dry matter content (%) of leaf
T_1	24.64 b	0.42 b	18.36 c	1.59 bc	18.11 b
T_2	24.01 c	0.45 b	22.82 b	1.68 ab	18.04 b
T_3	34.06 a	0.90 a	25.00 a	1.90 a	22.38 a
T_4	22.60 d	0.27 c	15.50 d	1.39 c	15.70 c
$LSD_{(0.05)}$	0.38	0.05	0.39	0.27	0.54
CV (%)	7.84	6.09	7.13	9.78	9.70

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: T_1 = 30 days old seedling, T_2 = 40 days old seedling, T_3 = 50 days old seedling, T_4 = 60 days old seedling

Table 4. Effect of number of plants per hill on leaf length, plant base diameter, fresh weight of leaves, foliage diameter and dry matter content of leaf of onion

Treatment	Leaf length (cm)	Plant base diameter (mm)	Fresh weight of leaves (g)	Foliage diameter (cm)	Dry matter content (%) of leaf
P_1	27.93 a	0.66 a	23.43 a	1.81 a	15.66 c
P_2	25.91 b	0.50 b	21.62 b	1.63 ab	20.95 a
P_3	25.14 c	0.38 c	16.20 c	1.48 b	19.07 b
$LSD_{(0.05)}$	0.33	0.05	0.34	0.24	0.46
CV (%)	7.84	6.09	7.13	9.78	9.70

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

4.6 Foliage diameter

Seedling of different age showed significant effect on foliage diameter of onion (Table 3 and Appendix VI). The largest foliage diameter (1.90 cm) was recorded from T_3 (50 days old seedling) treatment, which was statistically similar (1.68 cm) to T_2 (40 days old seedling) treatment. On the other hand, the smallest foliage diameter (1.39 cm) was observed in T_4 (60 days old seedling) treatment.

Different number of plants per hill showed significant influence on foliage diameter of onion (Table 4 and Appendix VI). The largest foliage diameter (1.81 cm) was recorded from P_1 (one plant/hill) treatment, which was statistically similar to (1.63 cm) P_2 (two plants/hill) treatment, while the smallest foliage diameter (1.48 cm) was observed in P_3 (three plants/hill) treatment.

Combined effect of seedling age and number of plants/hill had significant influence on foliage diameter of onion (Table 5 and Appendix VI). The largest foliage diameter (2.09 cm) was recorded from T_3P_1 (50 days old seedlings with one plant/hill) treatment, which was statistically similar to (1.86 cm) T_2P_1 (40 days old seedlings with one plant/hill) treatment and (1.85 cm) T_3P_2 (50 days old seedlings with two plants/hill) treatment. On the other hand, the shortest foliage diameter (1.20 cm) was observed from T_4P_3 (60 days old seedlings with three plants/hill) treatment.

4.7 Dry matter content of leaf

Present study revealed that there is a significant effect on total dry matter of leaves per plant of onion (Table 3 and Appendix VI). The maximum dry matter content of leaf (22.38 %) was recorded from T_3 (50 days old seedling) treatment, which was closely followed by (18.11 %) T_1 (30 days old seedling) treatment. In comparison, the minimum dry matter content of leaf (15.70 %)

was observed in T_4 (60 days old seedling) treatment and followed by (18.04 %) T_2 (40 days old seedling) treatment. The dry matter content for different age of seedlings varied possibly due to variation of growth pattern and photosynthesis at growing phase. The results of the present study are in partial agreement with Bhonde *et al.* (2001); they reported to have observed significant effect of age of seedling on plant height, bulb development, bulb weight, dry matter percentage, bulb yield and total soluble solids of onion.

Different number of plants/hill showed significant influence on dry matter content of leaves of onion (Table 4 and Appendix VI). The maximum dry matter content of leaf (20.95 %) was recorded from P_2 (two plants/hill) treatment and followed by (19.07 %) P_3 (three plants/hill) treatment. On the other hand, the minimum dry matter content of leaf (15.66 %) was observed in P_1 (one plant/hill) treatment. These findings are in agreement with the result of Rahman (2004).

Combined effect between age of seedling and number of plants/hill had significant effect on leaf dry matter of onion (Table 5 and Appendix VI). The highest dry matter of leaf (27.79 %) was recorded from T_3P_2 (50 days old seedlings with two plants/hill) treatment, which was closely followed by T_3P_3 (50 days old seedlings with three plants/hill) treatment (22.51 %). On the other hand, the lowest dry matter of leaf (13.39 %) was observed in T_4P_1 (60 days old seedlings with one plant/hill) treatment.

Table 5. Combined effect of seedling age and number of plants per hill on leaf length, plant base diameter, fresh weight of leaves, foliage diameter and dry matter content of leaf of onion

Treatments	Leaf length (cm)	Plant base diameter (mm)	Fresh weight of leaves (g)	Foliage diameter (cm)	Dry matter content (%) of leaf
T_1P_1	24.69 e	0.60 d	21.33 e	1.76 bc	17.00 f
T_1P_2	23.96 f	0.38 e	18.07 f	1.50 cd	18.05 e
T_1P_3	25.27 d	0.27 f	15.67 h	1.50 cd	19.28 cd
T_2P_1	23.52 g	0.57 d	26.20 c	1.86 ab	15.39 g
T_2P_2	23.87 fg	0.40 e	25.60 d	1.70 b-d	19.00 d
T_2P_3	24.63 e	0.39 e	16.67 g	1.47 de	18.05 e
T_3P_1	35.78 a	1.05 a	29.33 a	2.09 a	19.73 c
T_3P_2	33.27 b	0.95 b	27.33 b	1.85 ab	27.79 a
T_3P_3	33.12 b	0.69 c	18.33 f	1.75 bc	22.51 b
T_4P_1	22.30 h	0.40 e	16.87 g	1.51 cd	13.39 h
T_4P_2	19.48 i	0.27 f	15.49 h	1.47 de	16.85 f
T_4P_3	26.03 c	0.15 g	14.13 i	1.20 e	15.71 g
$LSD_{(0.05)}$	0.38	0.05	0.39	0.27	0.54
CV (%)	7.84	6.09	7.13	9.78	9.70

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: T_1 = 30 days old seedling, T_2 = 40 days old seedling, T_3 = 50 days old seedling, T_4 = 60 days old seedling and P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

4.8 Bulb length

In the present study, the length of bulb was significantly influenced by different age of seedling on bulb length of onion (Table 6 and Appendix VII). The maximum bulb length (4.60 cm) was recorded from T_3 (50 days old seedling) treatment and followed by (3.23 cm) T_2 (40 days old seedling) treatment, while the minimum bulb length (2.83 cm) was observed in T_4 (60 days old seedling) treatment. Length of bulb increased 50 days old seedlings were strong and larger in size at transplanting stage, search of more water and nutrients from the root zone to continue vegetative growth and increasing bulb length.

The variation due to the main effect of different number of plants/hill showed significant influence on bulb length of onion (Table 7 and Appendix VII). The longest length of bulb (3.95 cm) was recorded from P_1 (one plant/hill) treatment and followed by (3.58 cm) P_2 (two plants/hill) treatment, while the

smallest length of bulb (2.88 cm) was observed in P_3 (three plants/hill) treatment. Similar result was found by Rahman (2004) who observed that the bulb length per plant was the highest (2.59 cm) when one plant was grown per hill and the lowest (2.27 cm) was obtained when three plants were grown per hill. This result is in agreement with the results of Hiron (1983); he noted that the onion bulb size is decreased with the increasing plant population. Rahman (2008) also reported that the bulb length of onion per plant was the highest (2.32 cm) when one plant was grown per hill and the three plants per hill showed the lowest (2.19 cm) length of bulb of onion. Herison *et al.* (1993) observed that older seedlings produced larger plants at transplant and larger bulbs at harvest.

In case of combined effect of seedling age and number of plants/hill was also found to be significant on bulb length of onion (Table 8 and Appendix VII). The longest bulb length (5.50 cm) was recorded from T_3P_1 (50 days old seedlings with one plant/hill) treatment followed by (4.70 cm) T_3P_2 (50 days old seedlings with two plant/hill) treatment. On the other hand, the shortest bulb length (2.20 cm) was observed in T_4P_3 (60 days old seedlings with three plants/hill) treatment followed by (2.80 cm) T_1P_3 (30 days old seedlings with three plants/hill) treatment.

4.9 Bulb diameter

It can be seen from the result of the present experiment that different age of seedling showed significant influence on the bulb diameter of onion (Table 6 and Appendix VII). The maximum bulb diameter (5.60 cm) was found from T_3 (50 days old seedling) treatment and followed by (4.39 cm) T_2 (40 days old seedling) treatment. On the other hand, the minimum bulb diameter (4.22 cm) was observed in T_4 (60 days old seedling) treatment. Similar result was observed by Latif (2006), he reported that age of seedling significantly influenced the bulb diameter and other characters of onion and maximum diameter was obtained from 50 days old seedlings.

Significant variation in the bulb diameter was found due to different number of plants/hill of onion (Table 7 and Appendix VII). The maximum diameter of bulb (5.30 cm) was recorded from P_1 (one plant/hill) treatment and followed by (4.52 cm) P_2 (two plants/hill) treatment, while the minimum diameter of bulb (4.11 cm) was observed in P_3 (three plants/hill) treatment. The decreased diameter of bulb in case of more than one plant/hill was due to more competition for nutrients, air and water. These results are in conformity with the results of Herison *et al.* (1993), they obtained larger diameter bulbs when one seedling was transplanted per hill. Similar result was obtained by Rahman (2004). He reported that the diameter of onion bulb per plant was the maximum (4.22 cm) when one plant was grown per hill and the minimum diameter was obtained when three plants were grown per hill. Mohanty *et al.* (1990) reported that average yield, bulb diameter and bulb weight were highest (291.14-304.60 q/ha, 6.60-6.66 cm and 117.77-126.54 g, respectively) for the 20 Nov. and 5 Dec. transplanted seedlings. In both years, yield and bulb diameter increased with the age of seedlings over 6-weeks older were 95.75 % and 52.94 % respectively. Yu and Ts (1996) planted onion seedlings ranging from 25 to 60 days old. They observed quickest growth, earliest maturity and largest bulb from the seedlings aged 30 days old in China.

The combined effect of seedling age and number of plants/hill on bulb diameter differed significantly varying from 6.70 cm to 3.70 cm. (Table 8 and Appendix VII). The maximum bulb diameter (6.70 cm) was recorded from T_3P_1 (50 days old seedlings with one plant/hill) treatment and followed by (5.09 cm) T_3P_3 (50 days old seedlings with three plants/hill) treatment. On the other hand, the minimum bulb diameter (3.70 cm) was observed in T_4P_3 (60 days old seedlings with three plants/hill) treatment. Similar result was obtained by Oladiran and Sangodele (1996), they obtained widest bulb from transplanted at 6 weeks old seedling. Oladiran and Sangodele (1996) also reported that except cultivar Composite 4, other cultivar produced widest bulb from 6 weeks' old transplanted seedlings. Composite 4 gave better results at 4 weeks old seedlings.

Table 6. Effect of seedling age on bulb parameter of onion

Treatment	Bulb length (cm)	Bulb diameter (cm)	Bulb fresh weight (g)	Dry matter content (%) of bulb
T_1	3.20 b	4.36 b	55.59 c	15.70 b
T_2	3.23 b	4.39 b	57.34 b	16.35 ab
T_3	4.60 a	5.60 a	63.89 a	17.65 a
T_4	2.83 b	4.22 b	54.27 d	13.55 c
$LSD_{(0.05)}$	0.42	0.25	0.62	1.32
CV (%)	7.10	8.21	9.63	8.90

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: T_1 = (30 days old seedling) treatment, T_2 = (40 days old seedling) treatment, T_3 = (50 days old seedling) treatment, T_4 = (60 days old seedling) treatment

Table 7. Effect of number of plants per hill on bulb parameter of onion

Treatment	Bulb length (cm)	Bulb diameter (cm)	Bulb fresh weight (g)	Dry matter content (%) of bulb
P_1	3.95 a	5.30 a	54.12 c	13.84 c
P_2	3.58 b	4.52 b	60.01 a	16.91 a
P_3	2.88 c	4.11 c	59.19 b	16.68 b
$LSD_{(0.05)}$	0.33	0.22	0.53	0.19
CV (%)	7.10	8.21	9.63	8.90

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

4.10 Bulb fresh weight

Seedlings of different age showed significant effect on bulb fresh weight of onion (Table 6 and Appendix VII). The maximum fresh weight of bulb (63.89 g) was recorded from T_3 (50 days old seedlings) treatment and followed by (57.34 g) to T_2 (40 days old seedling) treatment. On the other hand, the minimum fresh weight of bulb (54.27 g) was observed in T_4 (60 days old seedling) treatment and followed by (55.59 g) T_1 (30 days old seedling) treatment. Ha *et al.* (1998) observed that seedling establishment was enhanced by young plug seedlings, higher rates of bolting and doubling of bulbs occurred with early sowing and old young seedlings. Herison *et al.* (1993) also observed that older seedlings produced larger plants at transplant and larger bulbs at

harvest. Singh and chaure (1999) found that optimum seedling age in terms of bulb weight was 6 weeks old.

The result showed highly significant effect of different number of plants/hill on bulb fresh weight of onion (Table 7 and Appendix VII). The maximum fresh weight of bulb (60.01 g) was recorded from P_2 (two plants/hill) treatment and followed by (59.19 g) P_3 (three plants/hill) treatment. On the other hand, the minimum fresh weight of bulb (54.12 g) was observed in P_1 (one plant/hill) treatment.

The combined effect of seedling age and number of plants/hill was found to have significant influence on bulb fresh weight of onion (Table 8 and Appendix VII). The maximum fresh weight of bulb (68.25 g) was recorded from T_3P_2 (50 days old seedlings with two plants/hill) treatment followed by (63.95 g) T_3P_3 (50 days old seedlings with three plants/hill) treatment. On the other hand, the minimum fresh weight of bulb (48.82 g) was observed in T_4P_1 (60 days old seedlings with one plant/hill) treatment.

4.11 Dry matter content of bulb

Significant variation in dry matter content of bulb at harvest stage was observed due to different age of seedling (Table 6 and Appendix VII). The maximum dry matter content of bulb (17.65 %) was recorded from T_3 (50 days old seedlings) treatment, which was statistically similar (16.35 %) T_2 (40 days old seedlings) treatment, while the minimum dry matter content of bulb (13.55 %) was observed in T_4 (60 days old seedlings) treatment. Dry matter content of bulb was found to decrease significantly due to older age of seedlings. This might be due to the fact that the optimum age of seedlings planted early had better growth, which resulted in higher production of dry matter content of bulb. Similar result was reported by Latif (2006), he reported that dry matter content of onion bulb was significantly influenced by the age of seedlings and found higher dry matter content (7.60 %) of bulb from 50 days old seedlings.

Different number of plants per hill showed significant influence on dry matter content of bulb of onion (Table 7 and Appendix VII). The maximum dry matter content of bulb (16.91 %) was recorded from P_2 (two plants/hill) treatment and followed by (16.68 %) P_3 (three plants/hill) treatment. On the other hand, the minimum dry matter content of bulb (13.84 %) was observed in P_1 (one plant/hill) treatment.

The combined effect of seedling age and number of plants/hill was found to be statistically significant on bulb dry matter content of onion (Table 8 and Appendix VII). The highest dry matter content of bulb (18.80 %) was recorded from T_3P_2 (50 days old seedlings with two plants/hill) treatment and followed by (18.56 %) T_3P_3 (50 days old seedlings with three plants/hill) treatment. On the other hand, the lowest dry matter of bulb (11.04 %) was observed in T_4P_1 (60 days old seedlings with one plant/hill) treatment.

Table 8. Combined effect of seedling age and number of plants per hill on bulb parameter of onion

Treatments	Bulb length (cm)	Bulb diameter (cm)	Bulb fresh weight (g)	Dry matter content (%) of bulb
T_1P_1	3.50 c	4.90 bc	54.77 g	12.80 i
T_1P_2	3.30 cd	4.37 de	57.48 e	17.12 e
T_1P_3	2.80 e	3.80 f	54.51 g	17.00 e
T_2P_1	3.50 c	4.82 c	53.67 h	13.24 h
T_2P_2	3.30 cd	4.52 d	59.50 c	18.28 c
T_2P_3	2.90 de	3.83 f	58.84 d	16.10 g
T_3P_1	5.50 a	6.70 a	59.47 c	17.30 d
T_3P_2	4.70 b	5.02 bc	68.25 a	18.80 a
T_3P_3	3.60 c	5.09 b	63.95 b	18.56 b
T_4P_1	3.30 cd	4.79 c	48.82 i	11.04 j
T_4P_2	3.00 de	4.17 e	57.53 e	16.34 f
T_4P_3	2.20 f	3.70 f	56.48 f	13.26 h
$LSD_{(0.05)}$	0.42	0.25	0.62	0.22
CV (%)	7.10	8.21	9.63	8.90

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: T_1 = (30 days old seedling) treatment, T_2 = (40 days old seedling) treatment, T_3 = (50 days old seedling) treatment, T_4 = (60 days old seedling) treatment and P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

4.12 Yield per plot

The effect of different age of seedlings on yield of onion per plot was found to be significant (Table 9 and Appendix VIII). The highest yield per plot (882.30 g) was recorded from T_3 (50 days old seedling) treatment, which was statistically similar to (817.30 g) T_2 (40 days old seedling) treatment. On the other hand, the lowest yield per plot (677.30 g) was observed in T_4 (60 days old seedling) treatment. The result is in agreement with the findings of Bhonde *et al.* (2001), they reported that use of 8 weeks old seedlings and harvesting at 125 days after transplanting gave the best yield, quality and highest net returns in case of onion. Verma *et al.* (1971) transplanted seedlings at the age of 4, 6, 8 and 10 weeks and observed that 8 weeks old seedlings gave the highest yield of bulb.

The bulb yield of onion per plot was also found to be significantly influenced by different number of plants/hill. (Table 10 and Appendix VIII). The maximum yield per plot (845.30 g) was recorded from P_2 (two plants/hill) treatment, which was closely followed by (834.30 g) P_3 (three plants/hill) treatment. On the other hand, the minimum yield per plot (692 g) was observed in P_1 (one plant/hill) treatment. The yield was found to increase with increasing number of plants/hill. This might be due to the fact increase in yield from more number of plants/hill to the increase in number of plants/unit area. Similar result was reported by Mondal and Brewster (1989).

Combined effect of seedling age and number of plants/hill had significant influence on yield per plot of onion (Table 11 and Appendix VIII). The highest yield per plot (940 g) was recorded from T_3P_2 (50 days old seedlings with two plants/hill) treatment followed by (928 g) T_2P_2 (40 days old seedlings with two plants/hill) treatment. On the other hand, the lowest yield per plot (552 g) was observed in T_4P_1 (60 days old seedlings with one plant/hill) treatment followed by (640 g) T_1P_1 (30 days old seedlings with one plant/hill) treatment.

Table 9. Effect of seedling age on yield of onion

Treatment	Yield per plot (g)	Yield (t/ha)
T_1	785.00 b	7.85 b
T_2	817.30 ab	8.17 ab
T_3	882.30 a	8.82 a
T_4	677.30 c	6.77 c
$LSD_{(0.05)}$	71.07	0.71
CV (%)	10.48	10.69

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: T_1 = (30 days old seedling) treatment, T_2 = (40 days old seedling) treatment, T_3 = (50 days old seedling) treatment, T_4 = (60 days old seedling) treatment

Table 10. Effect of number of plants per hill on yield of onion

Treatment	Yield per plot (g)	Yield (t/ha)
P_1	692.00 c	6.92 c
P_2	845.30 a	8.45 a
P_3	834.30 b	8.34 b
$LSD_{(0.05)}$	9.58	0.09
CV (%)	10.48	10.69

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

4.13 Yield

The effect of different age of seedlings showed significant influence on yield of onion (Table 9 and Appendix VIII). The maximum yield (8.82 t/ha) was recorded from T_3 (50 days old seedling) treatment, which was statistically similar to (8.17 t/ha) T_2 (40 days old seedling) treatment. On the other hand, the minimum yield (6.77 t/ha) was observed in T_4 (60 days old seedling) treatment.

The total yield of bulb of onion was significantly varied due to different number of plants/hill (Table 10 and Appendix VIII). The maximum yield (8.45 t/ha) was recorded from P_2 (two plants/hill) treatment followed by (8.34 t/ha) P_3 (three plants/hill) treatment. On the other hand, the minimum yield (6.92 t/ha) was observed in P_1 (one plant/hill) treatment. This result is in agreement with the results of Halder (2001), he found that two or three plants/hill produced significantly higher yield than one plant. The results of plant/hill are in

agreement with the findings of Tarafder (1999). He found that two or three or four plants/hill produced significantly higher yield than one plant/hill of carrot. Similar trend was obtained by Mandal *et al.* (1973), they found that two plants per hill gave better yield than that of one plant/hill.

Significant combined effect of seedling age and number of plants/hill on yield of onion was also observed (Table 11 and Appendix VIII). The highest yield (9.40 t/ha) was recorded from T_3P_2 (50 days old seedlings with two plants/hill) treatment followed by (9.28 t/ha) T_2P_2 (40 days old seedlings with two plants/hill) treatment. On the other hand, the lowest yield (5.52 t/ha) was observed in T_4P_1 (60 days old seedlings with one plant/hill) treatment. Maurya *et al*. (1997) reported that 50 days old seedlings gave the highest bulb yield of onion (282.22 q/ha) followed those planted at 60 days (238.89 q/ha). Liu *et al.* (1996) found that 55 and 65 days old seedlings were larger in size at transplanting and produced higher yields and matured earlier than 45 days old seedlings. Vaccani and Patel (1989) also found that bulb yield was the highest (462.3 q/ha) from transplanting of 7 weeks old seedlings and the lowest (257.7 q/ha) from transplanting of 4 weeks old seedlings. Patil *et al*. (1958) observed that when the transplanting age of Nasi Red onion was increased by one week from 7 to 14 weeks, there was progressive increase in yield in two out of three experimental years at Puna. They suggested that 56 to 63 days old seedling should be transplanted. Sharma (1998) observed that mean bulb yield increased significantly as seedling age at transplanting increased up to 6 weeks old. Singh and Chaure (1999) concluded that optimum seedling age in terms of bulb yield was 6 weeks old.

Table 11. Combined effect of seedling age and number of plants per hill on yield of onion

Treatments	Yield per plot (g)	Yield (t/ha)
T_1P_1	640 i	6.40 i
T_1P_2	865 d	8.65 d
T_1P_3	662 h	6.62 h
T_2P_1	805 g	8.05 g
T_2P_2	928 b	9.28 b
T_2P_3	850 e	8.50 e
T_3P_1	850 e	8.50 e
T_3P_2	940 a	9.40 a
T_3P_3	914 c	9.14 c
T_4P_1	552 j	5.52 j
T_4P_2	817 f	8.17 f
T_4P_3	663 h	6.63 h
$LSD_{(0.05)}$	11.07	0.11
CV (%)	10.48	10.69

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly by LSD at 0.05 levels of probability
Note: T_1 = (30 days old seedling) treatment, T_2 = (40 days old seedling) treatment, T_3 = (50 days old seedling) treatment, T_4 = (60 days old seedling) treatment and P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

4.14 Economic analysis

A detailed cost and return analysis was done according to the procedure of Alam *et al.,* (1989). The details of analysis were shown in Table 12 and Appendix IX. The input and overhead cost were recorded for all the treatments and calculated on per hectare basis. Input costs for land preparation, seed cost, organic manure, irrigation and manpower required for all the operations from planting to harvesting of onion were recorded for unit plot and converted into cost per hectare. Price of onion bulb was considered as per market rate. The economic analysis presented under the following headings-

4.14.1 Gross income

The combination of age of seedling and number of plant/hill showed different gross return. The highest gross return (Tk. 4,23,000) was obtained from T_3P_2 (50 days old seedling with two plants/hill) treatment and the second highest gross return (Tk. 4,17,600) was found in T_2P_2 (40 days old seedling with two

plants/hill) treatment. The lowest gross return (Tk. 2,48,400) was obtained from T_4P_1 (60 days old seedling with one plant/hill) treatment (Table 12).

4.14.2 Net return

In case of net return different treatment combination showed different concentration of net return. The highest net return (Tk. 2,66,984) was found from T_3P_2 (50 days old seedling with two plants/hill) treatment and the second highest net return (Tk. 2,61,584) was obtained from T_2P_2 (40 days old seedling with two plants/hill) treatment. The lowest (Tk. 1,03,584) net return was obtained T_4P_1 (60 days old seedling with one plant/hill) treatment (Table 12).

4.14.3 Benefit cost ratio

In the combination of age of seedling and number of plant/hill, the highest benefit cost ratio (2.71) was noted from T_3P_2 (50 days old seedling with two plants/hill) treatment and the second highest benefit cost ratio (2.68) was estimated from T_2P_2 (40 days old seedling with two plants/hill) treatment. The lowest benefit cost ratio (1.72) was obtained from T_4P_1 (60 days old seedling with one plant/hill) treatment (Table 12). From economic point of view, it was apparent from the above results that the combination of T_3P_2 (50 days old seedling with two plants/hill) treatment was more profitable than rest of the combination.

Table 12. Cost and return of onion cultivation as influenced by age of seedling and number of plant per hill

Treatment	Bulb yield (t/ha)	Gross income (Tk. /ha)	Cost of production	Net return (Tk. /ha)	Benefit Cost Ratio (BCR)
T_1P_1	6.40	2,88,000	1,44,816	1,43,184	1.99
T_1P_2	8.65	3,89,250	1,56,016	2,33,234	2.49
T_1P_3	6.62	2,97,900	1,67,216	1,30,684	1.78
T_2P_1	8.05	3,62,250	1,44,816	2,17,434	2.50
T_2P_2	9.28	4,17,600	1,56,016	2,61,584	2.68
T_2P_3	8.50	3,82,500	1,67,216	2,15,284	2.29
T_3P_1	8.50	3,82,500	1,44,816	2,37,684	2.64
T_3P_2	9.40	4,23,000	1,56,016	2,66,984	2.71
T_3P_3	9.14	4,11,300	1,67,216	2,44,084	2.46
T_4P_1	5.52	2,48,400	1,44,816	1,03,584	1.72
T_4P_2	8.17	3,67,650	1,56,016	2,11,634	2.36
T_4P_3	6.63	2,98,350	1,67,216	1,31,134	1.78

T_1 = (30 days old seedling) treatment, T_2 = (40 days old seedling) treatment, T_3 = (50 days old seedling) treatment, T_4 = (60 days old seedling) treatment and P_1 = 1 plant/hill, P_2 = 2 plants/hill, P_3 = 3 plants/hill.

Total cost of production was done in details according to the procedure of Krishitattik Fasaler Utpadon O Unnayan (in Bengali), by Alam *et al.* (1989), pp. 231-239.

Sale of marketable onion bulb @ Tk. 45,000/ton

Gross return = Marketable yield × Tk. /ton

Net income = Gross income – Total cost of production

BCR = Gross return ÷ cost of production

CHAPTER V

SUMMARY AND CONCLUSIONS

An experiment was conducted at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka-1207 in the Rabi season during the period from October 2014 to April 2015 to study the effect of age of seedlings and number of plants per hill on the growth and yield of onion (*Allium cepa* L.)**.**

The experiment consisted of four levels of age of seedling viz., 30 days old seedling, 40 days old seedling, 50 days old seedling and 60 days old seedling and three different levels of plants per hill viz., One plant per hill, two plants per hill and three plants per hill. The experiment consisting of 12 treatment combinations was laid out in Randomized Complete Block Design (RCBD) with three replications. The treatments were distributed randomly to the unit plots of each block. The size of each unit plot was 1m × 1m.

Seedling of different age showed significant influence on growth parameters, yield components and yield of onion bulbs. The maximum plant height (47.97 cm) at 40 DAT, number of leaves (11.33) at 40 DAT, leaf length (34.06 cm), plant base diameter (0.90 mm), fresh weight of leaf (25.00 g), foliage diameter (1.90 cm), dry matter of leaf (22.38 %), bulb length (4.60 cm), bulb diameter (5.60 cm), fresh weight of bulb (63.89 g), dry matter content of bulb (17.65 %), yield per plot (882.30 g) and yield (8.82 t/ha) were recorded from T_3 (50 days old seeedling) treatment. The minimum plant height (36.03 cm) at 40 DAT, number of leaves (8.53) at 40 DAT, leaf length (22.60 cm), plant base diameter (0.27 mm), fresh weight of leaf (15.50 g), foliage diameter (1.39 cm), dry matter of leaf (15.70 %), bulb length (2.83 cm), bulb diameter (4.22 cm), fresh weight of bulb (54.27 g), dry matter content of bulb (13.55 %), yield per plot (677.30 g) and yield (6.77 t/ha) were recorded from T_4 (60 days old seedling) treatment.

Different number of plants per hill showed significant influence on growth parameters, yield components and yield of onion bulbs. The maximum plant height (43.88 cm) at 40 DAT, leaf length (27.93 cm), plant base diameter (0.66 mm), fresh weight of leaves (23.43 g), foliage diameter (1.81 cm), length of bulb (3.95 cm) and diameter of bulb (5.30 cm) were recorded from one plant/hill. On the other hand, the maximum number of leaves (11.43) at 40 DAT, dry matter of leaf (20.95 %), fresh weight of bulb (60.01 g), dry matter content of bulb (16.91 %), yield per plot (845.30 g) and yield (8.45 t/ha) were recorded from two plant/hill. The minimum plant height (38.50 cm) at 40 DAT, number of leaves (8.20) at 40 DAT, plant base diameter (0.38 mm), shortest leaf length (25.14 cm), fresh weight of leaves (16.20 g), foliage diameter (1.48 cm), diameter of bulb (4.11 cm) and length of bulb (2.88 cm) were observed in three plants/hill. On the other hand, the minimum dry matter of leaf (15.66 %), fresh weight of bulb (54.12 g), dry matter content of bulb (13.84 %), yield per plot (692 g) and yield (6.92 t/ha) were observed in one plant/hill.

The combined effect of age of seedlings and number of plants/hill was found statistically significant on growth parameters, yield components and yield of onion bulbs. The maximum plant height (49.30 cm) at 40 DAT, plant base diameter (1.05 mm), leaf length (35.78 cm), fresh weight of leaves (29.33 g), foliage diameter (2.09 cm), bulb diameter (6.70 cm) and bulb length (5.50 cm) were measured from T_3P_1 (50 days old seedlings with one plant/hill) treatment. On the other hand, the maximum number of leaves (12.90) at 40 DAT, dry matter of leaf (27.79 %), fresh weight of bulb (68.25 g), dry matter content of bulb (18.80 %), yield per plot (940 g) and yield (9.40 t/ha) were recorded from T_3P_2 (50 days old seedlings with two plants/hill) treatment. The minimum plant height (33.90 cm) at 40 DAT, number of leaves (6.90) at 40 DAT, plant base diameter (0.15 mm), fresh weight of leaves (14.13 g), foliage diameter (1.20 cm), bulb diameter (3.70 cm) and bulb length (2.20 cm) were observed from T_4P_3 (60 days old seedlings with three plants/hill) treatment. On the other hand, the minimum leaf length (19.48 cm), dry matter of leaf (13.39 %), fresh weight of bulb (48.82 g), dry matter of bulb (11.04 %), yield per plot (552 g) and yield

(5.52 t/ha) were observed in T_4P_1 (60 days old seedlings with one plant/hill) treatment.

The highest gross return (Tk. 4,23,000/ha), net return (Tk. 2,66,984/ha) and benefit cost ratio (2.71) was obtained from T_3P_2 (50 days old seedling with two plants/hill) treatment and the lowest gross return (Tk. 2,48,400/ha), net return (Tk. 1,03,584/ha) and benefit cost ratio (1.72) was obtained from T_4P_1 (60 days old seedling with one plant/hill) treatment.

The following conclusion could be drawn:

- From the present study it may be suggested that, higher yield and economic return of onion could be obtained by cultivating the crop with transplanting of 50 days age of seedling with two plants/hill.

REFERENCES

Ahmad, K. (1976). Phul Phal o Shak Shabji (in Bengali) (3rd Ed.). Alhaj kamisuddin Ahmad. Bangalow No. 2, Farmgate, Dacca-15. Bangladesh. pp. 519-523.

Alam, M.S., Iqbal, M.T., Amin, M.S. and Gaffer, M.A. (1989). Production and improvement of agronomic crop (in Bangla). T.M. Jubair Bin Iqbal, Manik poteil, Megki, Sirajgonj. pp. 231-239.

Azam, M.G.N. (1989). Effect of number of vines planted per hill and systems of planting under different planting spacing on the growth and yield of sweet potato. M.S. Thesis, Dept. Hort., BAU, Mymensingh. pp. 28-32.

BBS. (2014). Yearbook of Agricultural Statistics of Bangladesh. 2013. 20th Ed. Bangladesh Bureau of Statistics. Statistics Division. Ministry of Planning, Govt. Peoples Republic of Bangladesh. Dhaka. p. 70.

BBS. (2013). Monthly Statistical Bulletin of Bangladesh (November, 2013). Statistics Division, Bangladesh Bureau of Statistics, Ministry of Planning, Govt. of Bangladesh, Dhaka. p. 53.

BBS. (2012). Yearbook of Agricultural Statistics of Bangladesh. 2011. 18th Ed. Bangladesh Bureau of Statistics. Statistics Division. Ministry of planning, Govt. Peoples Republic of Bangladesh. Dhaka. p. 77.

Bhonde, S.R., Chougule, A.B. and Singh, N.B. (2001). Studies on the effect of age of seedlings and date of harvesting on yield and quality of onion during late kharif season. News Letter National Hort. Res. Development Foundation. **21**(1): 27-30.

Bose, T.K., Som, M.G. and Kabir, J. (1993). Vegetables crops. Maya prokash, Calcutta. pp. 643-658.

Devies, G.N. and Jones, A.A. (1944). Experiments with transplant onion crop in California. *Bull. Calif. Agric. Exp. Sta*. **6**: 20.

Dragland, S. (1986). Plant density and row spacing in Carrots. Forskning og Forsoki Landbruket, statens Forskingsstasjon kise, Norway. **37**: 3, 139-145. [cited from Hort. Abstr., 59 (3): 59,1989].

Edris, K.M.A., Islam, T.M.T, Chowdhury, M.S. and Haque, A.K.M.M. (1979). Detailed Soil Survey of Bangladesh Agricultural University Farm, Mymensingh. Dept. Soil Survey, Govt. peoples republic Bangladesh.

FAO. (2013). FAO production Year Book, 2012. Food and Agriculture Organization of the United Nations. Rome, Italy. **56**: 155-156.

FAO. (1993). FAO Quarterly Bulletin of Statistics. Food and Agricultural Organization of the United Nations, Rome, Italy. **10**(3/4): 91-94.

Frost, D.J. and Kretchman, D.W. (1988). Plant spatial arrangement and density effects on small and medium vine processing tomatoes. *J. Amer. Soc. Hort. Sci.* **113**(1): 51-53.

Gomez, K.A. and Gomez, A.A. (1984). Statistical Procedures for Agricultural Research. 2nd edition. John Wiley and Sons lnc., New York. pp. 304-307.

Ha, I.J., Suh, J.K., Hwang, H.J., Kim, W.I. and Kim, B.S. (1998). Effect of sowing date and seedling age at planting on growth and yield for growing plug seedling in onion (*Allium cepa* L.). *J. Hort. Sci.* **40**(2): 90-97.

Halder, K.R. (2001). Effect of plant spacing, number of plants per hill and mulching on the growth and yield of carrot. M.S. Thesis, Dept. Hort., BAU, Mymensingh. pp. 29-75.

Haider, K.R.., Cozaceanu, K. and cazaceanu, J. (1991). The influence of the micronutrients boron and zinc on the production of carrots. *Lucr. Sti. Inst. Agron. Iasi.* pp. 223-230.

Hanlet, P. (1990). Taxonomy, evolution and history. In: Rabinowitch, H.D. and Brewster (eds) J.L., onions and Allied crops, CRC press, Boca Raton, Florida. **1**: 1-26.

Herison, C., Masabni, J.G. and Zandstra, B.H. (1993). Increasing seedling density, age and nitrogen fertilization increases onion yield. *Hort. Sci.* **28**(1): 23-25.

Herklots, G.A.C. (1972). Vegetables in South East Asia. George Allen and Unwin Ltd. London. p. 390.

Hiron, R.W.P. (1983). Multi-seedlings onion in hassy trays. Reviws of Kirton Experimental Horticulture Station for 1982. Pp. 22-33. [Cited form Hort. Abst. 559 (4): 325, 1985].

Islam, M.S. (1990). Effect of different time of planting and number of plantings per hill on plant growth, fruit yield and seed yield of tomato. *Ban. J. Agric.* **12**(2): 83-87.

Jones, H.A. and Mann, L.K. (1963). Onions and Their Allies. Leonard Hill Book Ltd., London. P. 286.

Khan, M.A.H. (1981). The effect of carbon dioxide enrichment on the pattern of growth and development in rice and mustard. Ph.D. Thesis, Royal Veterinary and Agricultural University, Copenhagen.

Latif, M.A. (2006). Effects of spacing and age of seedling on the growth and yield of summer onion. M.S. thesis, Dept. Hort., BAU, Mymensingh. pp. 32-33.

Liu, F., Chang, W., Liu, F.L. and Chang, W.N. (1996). Effects of plant size and seedling age on growth and development of onion (*Allium cepa* L.). Bulletin of National Pingtumg Polytechnic Institute, **65**(2): 1-6. (Cited from Hort. Abst., **67**(10): 1075, 1997).

Mandal, R.C., Singh, K.D. and Maini, S.B. (1973). Effect of plant density, fertility level and shoot number on tuber yield and quality of tapioca hybrids. *Ind. J. Agron.* **18** (4): 494-503.

Maurya, K.R., Singh, V.K. and Singh, R. (1997). Effect of age of seedlings on growth and yield of onion. *J. Appl. Biol.* **7**(1-2): 55-57.

McCollum, G.D. (1976). Evaluation of crop plants. Ed. N.W. Simmonds, Lonfman, London and New York. pp. 186-190.

McGeary, D.J. (1985). The effect of plant density on shape, size, uniformity, soluble solids content, and yield of onions suitable for pickling. *J. Hort. Sci.* **60**: 83-87.

Mohanty, B.K., Barik, T. and Dora, D.K. (1990). Effect of time of transplanting and age of seedling of onion (*Allium cepa* L.). *Indian J. Agril. Sci.* **34**(2): 111-113.

Mondal, M.F. and Brewster, J.L. (1989). Effects of shading and plant density on radiation inception, bulb development and yield of onion (*Allium cepa* L.). *Ban. Hort.* **17**(1): 5-10.

Nassar, M.A. (1986). Tomato fertilizer and production management trial. New Zealand Com. Grower. **38**(2): 28 [Cited from Hort., Abst, **53**(9): 628, 1983].

Oladiran, J. and Sangodel, S.E. (1996). Effect of cultivar and age of seedlings in onion as a Rabi crop. *Poona Agric. Coll. Mag.* **49**: 3-6.

Park, Y.B. and Lee, B.Y. (1989). Study on the growth and bulb formation of garlic plants (*Allium sativum* L.). *J. Korean Soc. Hort. Sci.* **30**: 2-6.

Patil A.K., Vijai, S. and Singh, V. (1958). Interaction effect of agronomical practices on kharif onion (*Allium cepa* L.). *Ind. New-Bot.* **27**: 1-4 & 115-118.

Prasad, V.V.S., Pandey, R.K. and Saxena, M.C. (1978). Physiological analysis of yield variation in gram (*Cicer arietinum* L.) genotypes. *Ind. J. Plant Physiol.* **21:** 228-234.

Pruthi, J.S. (1987). Spices and Condiments. National Book Trust, New Dehli, India. pp. 170-171.

Rahim, M.A. and Forhad, R. (1988). Effect of storage temperature on the initiation and development of garlic cloves (*Allium sativum* L.). *Sci. Hortic.* **37:** 25-38.

Rahim, M.A., Siddique, M.A. and Hossain, M.M. (1984). Effect of time of planting mother bulb size and plant density on the yield of garlic. *Ban. J. Agric. Res.* **9**: 112-118.

Rahman, A.K.M.M. and Talukder, M.R. (1986). Influence of date of planting and plant spacing on the growth and yield of garlic. *Ban. J. Agric.* **11**: 19-26.

Rahman, M.M. (1981). Effect of different dates of planting and plant spacing on the yield of garlic (*Allium sativum* L.). M.Sc. Thesis, Dept. Hort., BAU, Mymensingh, Bangladesh.

Rahman, M. Z. (2008). Effect of nitrogen and number of plants per hill on growth and yield of onion (*Allium cepa* L.). M. S. (Ag.) thesis, Department of Horticulture, SAU, Dhaka.

Rahman, M.S., Islam, M.A., Haque, M.S. and Karim, M.A. (2004). Effects of planting date and gibberellic acid on the growth and yield of garlic (*Allium sativum* L.). *Asian J. Plant Sci.* **3**(3): 344-352.

Rahman, Z. (2004). Effect of plant spacing and number of plants per hill on growth and yield of onion. M.S. thesis, Dept. Hort., BAU, Mymensingh. pp. 40-48.

Rashid, M.A. (1976). Bangladesher Sabji. Bangla Academy, Dacca, Bangladesh. p. 40.

Rosell, M.E., Grela, M.J. and Diazvaldes, O. (1987). Study of the optimum number of tomato plants per planting hill following direct sowing. *Centro Agricola*. **14**(1): 63-67. [Cited from Hort. Abstr., **48**(10): 6727, 1988].

Saladaga, F.P. and Rodolfo, G.E. (1987). Comparative evolution of traditional methods and recommended practice of planting sweet potato. *J. Trop. Res.* **9**(2): 104-109. [Cited form Biological Abst. 84 (10): 104-109, 1987].

Sharma, D.P. (1998). Effect of age of seedling and nitrogen levels on growth and yield of onion cv. Pusa Red (*Allium cepa* L.). *Adv. Plant Sci.* **11**(1): 237-239.

Siddique, M.A. and Rabbani, M.G. (1987). Effect of length of vine cutting, part of vine inserted into the soil of vines planting and number of vines planted per hill in sweet potato. *Thai. J. Agril. Sci*. **20**(4): 315-321.

Singh, J. and Chaure, N.K. (1999). Effect of age of seedlings and nitrogen levels on growth and yield of onion (*Allium cepa* L.). *Adv. Hort. Forest.* **6**: 73-77.

Singh. D.P. and Singh, R.P. (1974). Studies on the effect of time of sowing and age of seedlings on growth and yield of onion (*Allium cepa* L.). *Ind. J. Hort.* **31**(1): 69-73.

Tarafder, M.E.H. (1999). Effect of plant spacing and number of plants per hill on the growth and yield of carrot. M.S. Thesis, Dept. Hort., BAU, Mymensingh. pp. 25-54.

Thompson, N.C. and Kelly, W.C. (1985). Potential of cowdung producted from plant waste on the growth and nutrient status in vegetable production. *Int. J. Physical Sci.* **5**(13): 1964-1973.

Thompson, N.C. and Kelly, W.C. (1957). Vegetable crops. McGraw-Hill Book Co. Inc. New York. pp. 353-362.

Vaccani, M.U. and Patel, Z.G. (1989). Effect of age of seedlings on yield of onion bulbs. *Ind. J. Agron.* **34**(4): 433-434.

Vaccani, M.U. and Patel, Z.G. (1988). Studies on growth and yield of onion as affected by seedling age at transplanting. *Prog. Hort.* **20**: 3-4 & 297-298.

Verma, J.P., Rathore, S.V.S. and Yadav, B.S. (1971). Performance of bulb crop of onion as affected by sowing dates and age of transplants. *Prog. Hort.* **3**(2): 29-33.

Vik, J. (1974). Experiments with onion group transplants, onion sets and other factors influencing an early onion crop (*Allium cepa L.*) moldering fra Norges land brukshogskole, Agricultural University, Norway. **53**(30): 80. [Cited form Hort. Abst. **43** (8): 100, 1975].

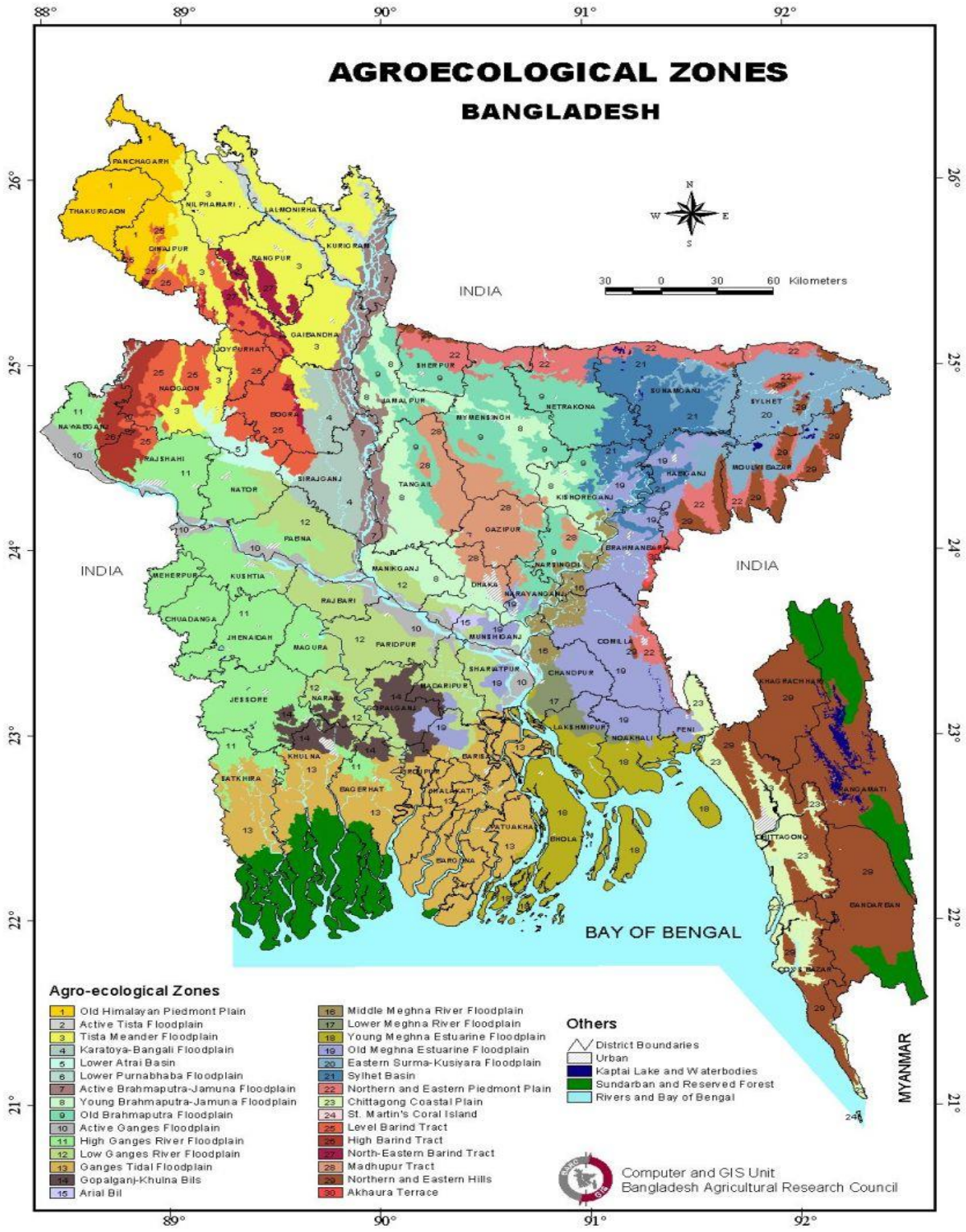
Watson, D.J. (1947). Comparative physiological studies on the growth of field crops. II. The effect of varying nutrient supply on the net assimilation rate and leaf area. *Ann. Bot.* **11**: 375-407.

Yawalkar, K.S. (1985). Vegetable Crops in India. Indian Agril. Hort. Publishing House, Nagpur. pp. 288-563.

Yu, C.H. and Ts, E.T.C. (1966). A study on seedling age in relation to bulbing of onions. *J. Agric. Ass. China*. **56**: 35-40.

APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh



Appendix II. Physical characteristics and chemical composition of soil of the experimental plot

Soil characteristics	Analytical results
Agrological Zone	Madhupur Tract
p^H	5.8 -6.5
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka

Appendix III. Monthly average record of air temperature, rainfall, relative humidity and Sunshine of the experimental site during the period from October 2014 to April 2015.

Month	Air temperature (°c)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximum	Minimum			
October, 2014	31.6	23.8	78	172.3	5.2
November, 2014	29.6	19.2	77	34.4	5.7
December, 2014	26.4	14.1	69	12.8	5.5
January, 2015	25.4	12.7	68	7.7	5.6
February, 2015	28.1	15.5	68	28.9	5.5
March, 2015	32.5	20.4	64	65.8	5.2
April, 2015	33.7	23.6	69	165.3	4.9

Source: Bangladesh Meteorological Department (Climate & Weather Division) Agargoan, Dhaka - 1212

Appendix IV: Error mean square values for plant height of onion at different days after transplanting (DAT)

Source of variation	Degrees of freedom	Plant height			
		20 DAT	30 DAT	40 DAT	Harvest
Replication	2	0.512	6.929	6.929	70.355
A	3	61.214*	258.021*	258.021*	262.010*
B	2	5.027*	121.587*	55.037**	79.470*
A × B	6	0.716**	6.669**	6.669*	3.795*
Error	22	1.949	15.077	15.077	36.725

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix V: Error mean square values for number of leaves per plant of onion at different days after transplanting (DAT)

Source of variation	Degrees of freedom	Number of leaves/plant			
		20 DAT	30 DAT	40 DAT	Harvest
Replication	2	0.008	0.612	0.401	0.737
A	3	3.909**	8.810*	12.801*	6.418**
B	2	0.268*	13.934**	9.808*	7.435*
A × B	6	0.087*	0.679*	0.368**	0.081*
Error	22	0.185	0.350	0.481	0.522

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VI: Error mean square values for leaf length, plant base diameter, fresh weight of leaves, foliage diameter and dry matter content of leaf of onion

Source of variation	Degrees of freedom	Leaf length (cm)	Plant base diameter (mm)	Fresh weight of leaves (g)	Foliage diameter (cm)	Dry matter content (%) of leaf
Replication	2	0.054	0.054	2.406	70.355	0.944
A	3	2.633*	0.700*	68.689*	262.010*	1340.745*
B	2	5.378*	4.104*	4.726*	79.470*	1623.569*
A × B	6	0.106*	0.049*	0.063*	3.795*	35.573*
Error	22	0.017	0.017	0.513	36.725	1.447

*Significant at 5% level of probability

Appendix VII: Error mean square values for bulb parameter of onion

Source of variation	Degrees of freedom	Bulb length (cm)	Bulb diameter (cm)	Bulb fresh weight (g)	Dry matter content (%) of bulb
Replication	2	0.016	0.003	0.054	0.200
A	3	19.888*	0.694*	3.298*	2.300*
B	2	184.347**	6.185*	11.310*	1.867**
A × B	6	3.123*	1.130**	1.238*	1.033*
Error	22	0.078	0.083	0.123	0.057

*Significant at 5% level of probability ** Significant at 1% level of probability

Appendix VIII: Error mean square values for yield of onion

Source of variation	Degrees of freedom	Yield per plot (g)	Yield (t/ha)
Replication	2	0.046	0.054
A	3	23.845*	2.633*
B	2	168.336*	5.378*
A × B	6	5.123*	0.106*
Error	22	0.2678	0.017

*Significant at 5% level of probability