EFFECT OF MULCH AND DIFFERENT LEVELS OF SULPHUR AND BORON ON THE GROWTH AND BULB YIELD OF ONION

SAJEED HASAN BAPPY

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

SHER-E-BANGLA NAGAR, DHAKA-1207, BANGLADESH

JUNE, 2020

EFFECT OF MULCH AND DIFFERENT LEVELS OF SULPHUR AND BORON ON THE GROWTH AND BULB YIELD OF ONION

BY

SAJEED HASAN BAPPY

REGISTRATION NO. 13-05301

A Thesis

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

MASTER OF SCIENCE (MS)
IN
HORTICULTURE

SEMESTER: JANUARY-JUNE, 2020

APPROVED BY:

..……	.....…….……
Prof. Dr. Khaleda Khatun	**Prof. Dr. Tahmina Mostarin**
Department of Horticulture	Department of Horticulture
Sher-e-Bangla Agricultural University	Sher-e-Bangla Agricultural University
Supervisor	**Co-Supervisor**

.....
Prof. Dr. Md. Jahedur Rahman
Chairman
Examination Committee

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

Ref. No.: Date:

CERTIFICATE

This is to certify that thesis entitled ***"EFFECT OF MULCH AND DIFFERENT LEVELS OF SULPHUR AND BORON ON THE GROWTH AND BULB YIELD OF ONION"*** *submitted to the* ***Department of Horticulture,*** *Sher-e-Bangla Agricultural University (SAU), Dhaka in partial fulfillment 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 SAJEED HASAN BAPPY, Registration No. 13-05301 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Dated: June, 2020
Place: Dhaka, Bangladesh

Prof. Dr. Khaleda Khatun
Department of Horticulture
Sher-e-Bangla Agricultural University,
Supervisor

DEDICATED
TO
MY BELOVED
PARENTS

ACKNOWLEDGEMENT

At first, the author takes the opportunity to express his deepest sense of gratefulness to Almighty Allah enables the author to complete his research work for the degree of Master of Science (MS) in Horticulture.

The author really does not have adequate words to express his heartfelt sense of gratification, ever indebtedness and sincere appreciation to his benevolent teacher and research supervisor, **Prof. Dr. Khaleda Khatun,** Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207, for his constant help, scholastic guidance, planning experiment, valuable suggestions, timely and solitary instructive criticism for successful completion of the research work as well as preparation of this thesis.

It is a great pleasure for the author to express his sincere appreciation, profound sense, respect and immense indebtedness to his respected co-supervisor, **Prof. Dr. Tahmina Mostarin** and Chairman, **Prof. Dr. Md. Jahedur Rahman**, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207, for providing him with all possible help during the period of research work and preparation of the thesis.

The author would like to express his deepest respect and boundless gratitude to all the respected teachers of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka-1207 for their sympathetic co-operation and inspiration throughout the course of this study and research work.

Cordial thanks are also due to all laboratory staff and field workers of SAU farm for their co-operation to complete his research work in the field.

The author deeply acknowledges the profound dedication to his beloved Parents and Sisters for their moral support, steadfast encouragement and continuous prayer in all phases of academic pursuit from the beginning to the completion of study successfully.

Finally, the author is deeply indebted to his friends and well-wishers especially Md. Abdus Samad and Abu Bakar Siddique for their kind help, constant inspiration, co- operation and moral support which can never be forgotten.

Date: June, 2020 The Author

SAU, Dhaka

EFFECT OF MULCH AND DIFFERENT LEVELS OF SULPHUR AND BORON ON THE GROWTH AND BULB YIELD OF ONION

BY
SAJEED HASAN BAPPY

ABSTRACT

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October, 2018 to March, 2019 to find out the growth and yield of onion as influenced by sulphur and boron with mulch materials. The experiment consisted of two factors: Factor A: Four doses of Sulphur and Boron fertilizer viz. F_0 = $S_{0kg}B_{0kg/ha}$ (Control), F_1 = $S_{20kg}B_{1kg/ha}$ (Sulphur 20 kg/ha and Boron 1 kg/ha), F_2 = $S_{40kg}B_{2kg/ha}$ (Sulphur 40 kg/ha and Boron 2 kg/ha), F_3 = $S_{60kg}B_{3kg/ha}$ (Sulphur 60 kg/ha and Boron 3 kg/ha) and Factor B: Four types of mulch viz. M_0 = No mulch and no irrigation, M_1 = Black polythene, M_2 = Water hyacinth and M_3 = Rice straw. There were 16 treatment combinations and experiment was setup in Randomized Complete Block Design (RCBD) with three replications. In case of Sulphur and Boron treatment, the highest plant height at 60 DAT (53.38 cm), maximum leaf number (10.48) at 60 DAT, highest bulb length (4.83 cm), maximum neck diameter (1.31 cm), longest root length (7.78 cm), highest dry matter content (15.98%), highest fresh leaf weight (26.82 g), dry matter content of leaf (24.74 %), single bulb weight (39.93 g), yield per plot (0.80 kg) and yield per hectare (9.98 t) were obtained from F_3 treatment. Similarly, among the mulch materials, highest plant height at 60 DAT (52.51 cm), maximum leaf number (10.19), highest bulb length (4.52 cm), highest bulb diameter (5.74 cm), maximum neck diameter (1.26 cm), longest root length (7.39 cm), the highest fresh leaf weight (25.61 g), dry matter content of leaf (23.35 %), single bulb weight (39.05 g), yield per plot (0.78 kg) and yield per hectare (9.76 t) were obtained from M_1 treatment. In combined effect, highest plant height at 60 DAT (55.54 cm), maximum leaf number (11.47), longest bulb length (5.51 cm), highest bulb diameter (6.68 cm), maximum diameter of neck (1.42 cm), longest root length (7.90 cm), highest fresh leaf weight (29.30 g), dry matter content of leaf (27.48 %), single bulb weight (42.40 g), yield per plot (0.85 kg) and yield per hectare (11.21 t) were obtained from F_3M_1 treatment. The highest gross return (Tk. 3,36,300/ha), net return (Tk. 1,88,934/ha) and benefit cost ration (2.28) was obtained from the treatment combination F_3M_1 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) compare with the rest of the treatment combinations. For growth, yield and economic point of view, it is apparent the F_3M_1 treatment was suitable for onion cultivation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
AEZ	Agro-Ecological Zone
Agric.	Agriculture
Agril.	Agricultural
BBS	Bangladesh Bureau of Statistics
BCPC	British Crop Production Council
cm	Centi-meter
CV	Coefficient of variation
^{0}C	Degree Celsius
df	Degrees of freedom
DAT	Days After Transplanting
et al.	And others
FAO	Food and Agriculture Organization
g	Gram
ha	Hectare
CRSP	Collaborative Research Support Program
J.	Journal
kg	Kilogram
LSD	Least Significant Difference
mg	Milligram
MP	Muriate of Potash
RCBD	Randomized Complete Block Design
SAU	Sher-e-Bangla Agricultural University
TSP	Triple Super Phosphate

CHAPTER I

INTRODUCTION

Onion (*Allium cepa* L.) is by far the most important of the bulb crops and is one of the important popular vegetable crops in the world (FAO, 2016). But in Bangladesh, it is extensively used as a spice for cooking purposes. The top most producer of onion in world is China, India, USA, Japan and Spain (FAO, 1993).

An edible portion of 100 g onion bulb contains 1.4 g protein, 11.2 g carbohydrate, 12 mg ascorbic acid, fiber (0.6 g), moisture (86.8 g) and several vitamins like vitamin A (0.012 mg), vitamin C (11 mg), thiamine (0.08 mg), riboflavin (0.01 mg), niacin (0.2 mg) and also some minerals like phosphorus (39 mg), calcium (32 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (157 mg) and 49 calories (Encyclopedia, 2017; Suresh, 2007). Recently, research has suggested that onions in the diet play a vital role in preventing heart diseases and other ailments (Encyclopedia, 2017).

Among the spices grown in Bangladesh, onion ranks first in respect of production and second in respect of acreage (MoA, 2016). It is grown in almost all the districts of Bangladesh, but it is commercially cultivated in the greater districts of Faridpur, Rajshahi, Dhaka, Mymensingh, Comilla, Jessore, Rangpur and Pabna (Anonymous, 1998). Onion production in Bangladesh during the year of 2013-2014 was 13,87,000 metric tons from 3,73,000 acre of land with an average yield of 3,718 kg/acre (BBS, 2016). With the increase of population, the demand as well as the import of onion is increasing day by day but due to limitation of land it is not possible to raise the production of the crop horizontally. The expansion of onion cultivation will hamper the cultivation of other profitable crops particularly rice, the staple food grain of Bangladesh. The only way to solve the problem is to increase per hectare yield. The

average yield per hectare is about 6.82 tons which is much lower than other developed countries where average production is over 17.5 t ha^{-1} (FAO, 2016).

Successful onion cultivation largely depends on the optimum cultural management practices. This includes judicious application of manures and fertilizers, efficient use of available soil moisture, spacing and time of planting. Soil fertility is the main factor for increasing production of any crop. Soil nutrient management is therefore, a very vital area of research. Researcher's opinion that some secondary and trace elements like sulpher and boron can play a vital role in increasing the yield of onion seed (Singh and Pandy, 2005). Onion is a sulphur loving plant and is required much for proper growth and yield of onion (Kumar and Singh, 1995). Sulphur has been found not only to increase the bulb yield of onion but also improves its quality, especially pungency and flavors (Jaggi and Dixit, 1999). Nasreen and Huq (2005) reported that sulphur levels up to 45 kg/ha increased the S uptake throughout the season and also produce the highest bulb yield. Boron has been linked with initiation and development of growing points, movement of sugars and starches to developing parts, movement of nutrient elements within the plant, formation of plant hormones affecting growth, root growth and health of fleshy roots, flower and fruit set and quality and flavor of vegetables (Vitosh *et al.,* 2001). Boron is also required in the translocation of sugars, starches, nitrogen and phosphorus and synthesis of amino acids and proteins (Varma *et al.,* 2005).

Out of these, efficient use of soil moisture is very important, because rainfall is scanty during Rabi season in Bangladesh when farmers grow this valued crop. Onions are rather sensitive to drought stress (Zayton, 2007). The crop requires 350-500mm of water over the growing season (FAO, 2013) hence adequate moisture possibly through irrigation is important in the production of onions. Onion root system is

shallow so it extracts very little water from depths beyond 60 cm. Further, growers have to depend either on natural precipitation or supplemental irrigation for growing onion. On the other hand, irrigation feasibilities are not sufficient in all the regions of the country. As a result, the production of onion is hampered to a great extent. Conservation of soil moisture may help in preventing the loss of water through evaporation permitting maximum utilization of moisture by plants. However, onion growth and development is greatly influenced by mulching and irrigation (Rahman *et al.*, 2013). Use of various mulches like black polythene, transparent polythene, rice straw, saw dust, water hyacinth reported to conserve soil moisture efficiently in garlic and onion as reported by many workers (Jamil *et al.*, 2005; Anisuzzaman *et al.*, 2009; Islam *et al.*, 2010; Inusah *et al.*, 2013).

In consideration with the above situations, the present research work has been undertaken to study the effects of boron and sulpher with mulch materials on growth and yield of onion with the following objectives:

- To find out the effect of sulphur and boron on the growth and bulb yield of onion.
- To determine the effect of mulch materials on growth and bulb yield of onion.
- To identify the suitable combination of sulphur and boron with mulching for better growth and maximum bulb yield of onion.

CHAPTER II

REVIEW OF LITERATURE

Some research works regarding mulching and fertilizers were done in home and aboard. But a little work has been done on this crop with the combined effect of mulching and fertilizers on the growth and yield of onion. However, available information portioning to this study was reviewed in the following sub headings.

2.1. Effect of Sulpher on Onion

Sharma *et al.* (2002) conducted an experiment on the sulphur status and response of onion *Allium cepa.* The effects of S rate (0, 15, 30, 45 and 60 kg/ha) on the yield and nutrient uptake by 28-day-old onion cv. Pusa Red grown on light or heavy-textured soil were also studied in a pot culture experiment. Plant height increased with the increase in S rate up to 30 kg/ha in heavy-textured soils and up to 45 kg/ha in light-textured soils.

Shakirullah *et al.* (2002) conducted an experiment on the effect on different levels of sulpher on yield and pungency of onion. Maximum plant height (66.44 cm) was observed in plot with 100 kg S/ha and minimum plant height (56.66 cm) was observed in control.

Kumar and Singh (1999) conducted an experiment on the deficiency symptoms in onion plants. They observed plants which received S were healthy, developed a good root system. Plants grown under S-deficient conditions had produced fewer rootlets, compared with S-treated plants.

Jaggi (2005) observed leaf number plant^{-1}, dry weight of bulb, dry weight of leaves per plant increased with increasing S rates up to 30 kg ha^{-1}.

Smriti *et al.* (2002) conducted an experiment on the effect of sulpher and boron nutrition on growth, yield and quality of onion (*Allium cepa* L.). The number of leaves, leaf length, leaf width significantly increased up to 40 kg S/ha and 1 Kg B/ha.

Meena and Singh (1998) showed that S and Zn treatments significantly enhanced the dry weight of onion bulbs. A sulpher dose of 20 mg S kg^{-1} on S-deficient soils and 10 mg S with 5 mg Zn kg^{-1} for low S soils was appropriate for better onion yields.

Nasreen *et al.* (2003) conducted a field experiment to study the effect of seven levels of sulpher (0, 15, 30, 45, 60, 75 and 90 kg ha^{-1}) on crop growth rate (CGR) at various stages of growth, yield components and bulb yield of onion. CGR values were increased progressively over time reaching peak at 60-75 DAT and thereafter declined sharply till 105 DAT. Highest CGR were obtained 45 kg S ha^{-1} along with a blanket dose of 120 kg N, 90 kg P_2O_5, 90 kg K_2O, 5 kg Z ha^{-1} plus 5 t cowdung ha^{-1}.

Yadav *et al.* (2004) treated onion cv. Pusa Red plants with sulfur (15 and 30 kg/ha). Onion bulbs were biggest (20.20 cm) with the application of 30 kg S/ha.

Sharma *et al.,* (2002) observed bulb diameter increased with the increase in S rate up to 30 kg ha^{-1} in heavy textured soils and up to 45 kg ha^{-1} in light textured soils.

Nagaich *et al.* (1999) studied the effects of 4 doses each of sulpher (0, 20, 40 and 60 kg/ha) and potassium (0, 40, 80, 120 kg/ha). Application of 60 kg S/ha significantly increased horizontal and vertical diameters of the bulb over the control. Application of 80 kg K_2O/ha significantly increased horizontal diameter of the bulb.

Tao *et al.* (2006) conducted a pot experiment to investigate the yield and pungency of spring onion. Two levels of N and S were applied to the soil in factorial combinations of 50 and 250 mg N kg^{-1} soil and 0 and 60 mg S kg^{-1} soil. Shoot dry-matter, yield was significantly affected by added N, but not by S. In soil of high S and low P

availability had a profound influence on both the yield and the pungency of spring onion.

Qureshi and Lawande (2006) conducted an experiment on the response of onion to sulfur application for yield, quality and its storability in S-deficient soils. In this experiment elemental sulfur (15, 30, 45, 60 and 75 kg/ha) was applied along with 100 kg N/ha, 50 kg P/ha and 50 kg K/ha. Onion responded significantly to 30-75 kg S/ha. The highest bulb yield of 39.1 t/ha was recorded with the application of 75 kg S/ha.

Smriti *et al.* (2002) carried out a field experiment to study the effect of S and B on the growth, yield and quality of onion cv. Nasik Red. The treatments comprised S at 0, 20, 40 and 60 kg/ha; and B at 0, 1 and 2 kg/ha. Bulb yield increased up to 40 kg S/ha and 1 kg B/ha.

2.2. Effect of boron on onion

Howlader *et al.* (2010) conducted a field experiment at Spices Research Sub-center Faridpur, during 2009 - 2010 to find out the requirement of P, K & B for higher seed yield of BARI Piaz–l. Different treatments showed significant effect on onion seed yield. The highest seed yield was obtained from T_9 (P_{50}, K_{120} and B_2 kg/ha + 20% B extra).

A field experiment was conducted at the field laboratory of USDA Alliums project, Horticulture Farm, Bangladesh Agricultural University, Mymensingh, during October 2009 to April 2010, to study the effects of boron and molybdenum on yield and quality of onion seed (*Allium cepa* L.) cv. BARI Piaz-1. The experiment was conducted with four levels of boron *viz.,* 0, 2, 4 and 6 kg/ha and four levels of molybdenum *viz.*, 0, 2, 4 and 6 kg/ha. The treatment combination, boron at 4 kg/ha with molybdenum at 4 kg/ha produced the highest seed yield (695.6 kg/ha) and germination of onion seed 92.3% (Saieed *et al.,* 2010).

A field experiment was conducted by Rashid *et al.* (2007) at Spices Research center Bogra, during 2006 - 2007 to find out the requirement of S and B for plant height, number of leaves, number of flowers per umbel, number of fruits per umbel, higher seed yield of BARI Piaz–l. The treatments comprised five levels of S at 0, 20, 40, 80 and 100 kg/ha and five levels of B at 0, 1, 3, 5 and 7 kg/ha as borax. The treatment combination of 100 kg S + 5 kg B/ha gave the highest seed yield.

Chowdhury *et al.* (2004) conducted an experiment at Field Laboratory of USDA Alliums Project, Horticulture Farm, Bangladesh Agricultural University, Mymensingh, during 2003 - 2004 to study the effects of boron and sulphur on seed production of onion (*Allium cepa* L.) cv.Taherpuri. The experiment was conducted with five levels of boron, viz., 0, 1, 2, 3 and 4 kg/ha and five levels of sulphur, viz., 0, 20, 40, 80 and 160 kg/ha. The highest seed yield was recorded from 4 kg B/ha. The positive effects of boron were found in order of 4 > 3 > 2 > 1 > 0 kg/ha. The sulphur at 80 kg/ha produced the highest seed yield. The positive effects of sulphur were found in order of 80 > 40 > 20 > 160 > 0 kg/ha. Among the treatment combinations, boron at 4 kg/ha with sulphur of 80 kg/ha produced the highest seed yield.

Chattopadhyay and Mukhopadhyay (2004) conducted an experiment on the response of onion seed crop to boron and molybdenum as foliar feeding in West Bengal, India. They showed that foliar application of boron at 0, 0.26, 0.56 and 1.12 kg/ha and molybdenum at 0, 0.10, 0.20 and 0.40 kg/ha had pronounced effect on plant height and bulb production. Application of boron as boric acid at the rate of 0.3% significantly increased bulb yield over plants that were not sprayed. The highest bulb production (280.1 q/ha) was recorded from the spray of 1.12 kg B/ha. Molybdenum increased the bulb yield progressively from 5.1 to 8.7% over plants that were not

treated with molybdenum. The interaction effect of boron and molybdenum was not significant in bulb production.

A field experiment was conducted in Bihar, India, during 1998-99 and 1999-2000 to study the effect of S and B on the growth, yield and quality of onion cv. Nasik Red. The treatments comprised S at 0, 20, 40 and 60 kg/ha and B at 0, 1 and 2 kg/ha. Plant height, the number of leaves, leaf length, leaf width, bulb size, bulb weight and bulb yield significantly increased up to 40 kg S/ha and 1 kg B/ha. The neck thickness and storability decreased with increasing levels of S but increased with increasing levels of B. The treatment combination of 40 kg S + 1 kg B/ha gave the highest net return and benefit:cost ratio (Smriti *et al.* 2002).

Mukhopadhyay and Chattopadhyay (1999) conducted an experiment with the effects of boron and molybdenum on growth and yield of onion in West Bengal, India. Three doses of boron (0.56, 1.12 and 2.24 kg/ha) were applied. The highest yield of bulbs (31.49 t/ha) was found at the highest level of boron. The response to molybdenum at different levels was less pronounced than that to boron. The plants at 2.24 kg B/ha and 0.40 kg Mo/ha gave the highest yield (33.06 t/ha), which was 63.3% greater than that of control.

2.3. Effect of mulch materials on growth and yield of onion

Singh *et al.* (2017) observed the influence of different mulching on the growth and yield of onion. Treatments of the experiment were seven types of mulching such as control (M_o), Rice straw (M_1), Water hyacinth (M_2), Baggage straw (M_3), Wheat straw (M_4), Grass straw (M_5) and Pipal leaf straw (M_6). The results revealed that growth parameters viz. plant height, no. of leaves, bulb length, bulb diameter, bulb weight and bulb yield were increased significantly with adopting mulching. The maximum plant height, no. of leaves, bulb length, bulb diameter, bulb weight and

bulb yield were recorded under Pipal leaf straw. Interestingly, the plant height, no. of leaves, bulb length, bulb diameter, bulb weight and bulb yield did not show significantly differences between M_6 and M_3. So, mulching with Pipal leaf straw and water hyacinth numerically gave the highest yield 38.00 t/ha, 38.40 t/ha and 37.50 t/ha., 37.60 t/ha during both year of experimentation, respectively.

Inusah *et al.* (2013) observed the influence of mulching with different straw materials, on the yields and productivity of onions, variety „White Creole". The trial comprised three treatments: No Mulch (T_1), mulching with Andropogan grass straw (T_2) and mulching with rice straw (T_3) at three tons per hectare each. The soil of the experimental field was categorized as sandy loam, with pH 5.8. The results of the trial indicated that different types of organic based mulch such as grass and rice straw could contribute significantly to improved onion productivity and yields under tropical conditions. Onion bulb yield of T_2 (10.58 t ha^{-1}) was significant ($P<0.05$) and over 60% higher than T_3 (6.63 t ha^{-1}); and over 230% greater than T_1 plot yields (3.20 t ha^{-1}). Analysis of the economic returns of the mulching technologies revealed a benefit-cost ratio of 2.31 and marginal rate of returns of 140 for T_2, suggesting that this technology is dominant over T_3 or T_1 technologies and is therefore recommendable to irrigated onion farmers.

An experiment was done by Hamma (2013) at the Teaching and Research Farm of the Institute for Agricultural Research, Ahmadu Bello University, Zaria. The experiment was laid out in a split plot design and was replicated three times; keeping planting dates of 15th October, 30th October, 14th November and 29th November in the main plot and mulching types; white polythene, black polythene, water hyacinth and control in sub-plots. NPK 20-10-10 fertilizer at rates of 150, 100 and 50 kg ha-1 were applied to grow the crop in three splits. The first dose was applied a week before

transplanting during land preparation, while the second and third doses were applied four and seven weeks after transplanting, respectively. It was observed that planting date of 15th October and white polythene mulch significantly produced higher treatment means than the rest of the treatments. On the other hand, planting date of 29th November and the control treatment under mulching types significantly produced lower treatment means among treatments throughout the period of observations.

Rahman *et al.* (2013) conducted an experiment to evaluate the influence of mulching (M) on the growth and yield of onion (*Allium cepa* L.) cv. Taherpuri. Treatments of the experiment were three types of mulching such as no mulch or control (M_0), rice straw (M_s) and water hyacinth (M_w). The results indicated that growth parameters such as plant height and number of leaves at different days after transplanting, dry weight of leaf, pseudostem and root were increased significantly with the application of mulching (M). Mulching of soil with straw (M_s) and water hyacinth (M_w) increased the length and diameter of bulb, fresh weight and dry weight of bulb and bulb yield. Interestingly, the bulb yield did not show significant differences between Ms and Mw. But mulching with water hyacinth numerically gave the highest yield (10.46 t /ha) than the mulching with rice straw (9.78 t /ha). Therefore, the use of water hyacinth as mulching material may be applied to grow onion.

Islam *et al.* (2010) observed that the effect of mulch (non-mulch and straw mulch) and different levels of nitrogen (0, 40, 80 and 120 kg ha^{-1}) and potassium (0, 37.5, 75 and 112.5 kg ha^{-1}) on the growth and yield of onion. Plants grown with straw mulch gave higher bulb yield (10.89 t ha^{-1}) which showed 13.79% increase over non-mulch. Nitrogen and mulch together produced significant variations. The Nitrogen at the highest level (120 kg ha^{-1}) along with straw mulch gave the highest yield (13.31 t ha^{-}

^{1}). Potassium together with mulch also exhibited significant variation on yield and yield components. Plants grown with the highest level of potassium (112.5 kg ha^{-1}) along with straw mulch gave the highest bulb yield (11.58 t ha^{-1}). Nitrogen and potassium as 120 kg N ha^{-1} × 75.0 kg K ha^{-1} gave the highest bulb yield (13.07 t ha^{-1}). Nitrogen and potassium at their maximum levels with straw mulch gave the highest bulb yield (14.67 t ha^{-1}).

Anisuzzaman *et al.* (2009) observed the effects of planting time and mulches on bulb growth and seed production of onion (*Allium cepa* L.) cv. Taherpuri. Planting time and mulches had significant influence on almost all parameters studied. Onion planted on 21 November had better agronomic traits contributing towards yield formation. Growth and seed production was accelerated by black polythene. Seed yield (460.81 kg ha^{-1}) was highest in the plots planted on 21 Nov. Seed yield was 529.06 kg ha^{-1} where black polythene mulch was used.

Woldetsadik *et al,* (2003) condected an experiment with shallot (*Allium cepa* var. ascalanicum Baker) on heavy clay soil to evaluate growth and yield response to mulching and nitrogen fertilization under the sub humid tropical climate of eastern Ethiopia. The treatments included wheat straw, clear and black plastic mulches, and an unmulched control, each with nitrogen rates of 0, 75, or 150 kg ha^{-1}. Straw and black plastic mulches increased soil moisture while clear plastic reduced it considerably. Weed control was best with black and clear plastics in the short season and with black plastic or straw mulch in the main season. Both plastic mulches elevated soil temperature, especially clear plastic, which also caused most leaf tip burn. Yield increased nearly three-fold with the black plastic mulch in the short season and by one fourth in the main season compared to the bare ground. The straw and clear plastic mulches increased yield during the short season, but slightly reduced

yield in the main season. The growth and yield of shallot were related to the weed control and soil moisture conservation efficiency of the mulches. Mulching did not alter the dry matter and the total soluble solids contents of the bulbs. Nitrogen fertilizer increased leaf numbers, plant height, mean bulb weight, bulb dry matter, and total soluble solids while reducing marketable bulb number, but did not significantly affect yield, leaf tip burn, or weed abundance.

Haque *et al.* (2003) observed the effect of natural and synthetic mulches on yield of local and exotic cultivars. The results revealed that significant variation exist among the different mulches in respect of morphological characters, yield contributing characters and yield of garlic. Water hyacinth mulch produced the tallest plant with higher number of leaves and roots per plant, higher fresh and dry weight of bulb, length of bulb and highest yield per hectare. Bulb diameter and number of cloves per bulb were higher in black polythene mulch. The exotic cultivar performed better than the local cultivar in respect of plant height, number of leaves and roots per plant, fresh and dry weight of bulb and yield per hectare.

Vavrina and Roka (2000) observed in 4 years of research comparing production of short-day onions (*Allium cepa* L.) on plastic mulch versus bare ground in southern Florida, greater marketable yields were obtained when onions were grown on plastic mulch. Results showed that in a semitropical environment, white-on-black plastic mulch provided the greatest yield enhancement from increased weight and bulb size. Yield loss due to splitting, while apparent, was not sufficient to reduce the impact of mulch on the increase in individual bulb weight.

2.4. Combine effect of mulch materials and fertilizers on growth and yield of onion

Azed *et al.* (2015) stated the effects of mulching and some fertilizers (boron/B and zinc/Zn) on the growth and yield of onion. The trial with one onion cultivar (Taherpuri) involved two separate experiments using different micronutrient levels (3 levels of B: 0, 0.20, 0.40 gm^{-2} and 4 levels of Zn: 0, 0.50, 0.80, 1.25 gm^{-2}) with plastic mulch without irrigation, and without mulch with irrigation. Results demonstrated that most of the yield and yield contributing parameters were significantly influenced by applying plastic mulch, and different doses of B and Zn. The plant height (35.55 cm) at 60 DAP (days after planting), number of leaves (5.53), fresh weight of leaves (12.13 g), dry weight of leaves (1.41 g), fresh weight of bulb (27.78 g), dry weight of bulb (2.54 g), pseudo-stem diameter (1.16 cm), diameter of bulb (4.04 cm), and bulb yield (14.86 tha^{-1}) were found to be greater when grown in plastic mulching. Interaction between mulching and boron, mulching and zinc, boron and zinc, and mulching and boron with zinc at different levels had significant effects on all growth and yield parameters with few exceptions. The combination of the highest doses of B at 4 $kgha^{-1}$ and Zn at 12.50 $kgha^{-1}$ with plastic mulching gave higher yield (18.71 tha^{-1}) of onion bulb and other parameters than those of yield without mulching (15.56 tha^{-1}). However, it can be concluded that most of the yield contributing characters and yield were significantly influenced by plastic mulching along with the interaction effect of different levels of B and Zn with it.

CHAPTER III

MATERIALS AND METHODS

This chapter arranges the materials and methods including a brief description of the experimental site, onion variety, soil, climate, land preparation, experimental design, treatments, and cultural operations, collection of soil and plant samples etc. and analytical methods used for the experiment. The details of research procedure are described here.

3.1. Description of the experimental site

3.1.1. Location

The research work was conducted in rabi season at Sher-e-Bangla Agricultural university Farm. Sher-e-Bangla Nagar. Dhaka-1207 during the rabi season of October. 2018 to March 2019. It is located at 90.2^0N and 23.5^0E latitude. The specific location of experimental site is presented in Appendix 1.

3.1.2. Soil

The soil of the experimental field belongs to the Tejgaon series of AEZ No. 28, Madhupur Tract and has been classified as Shallow Red Brown Terrace Soils in Bangladesh soil classification system. A composite sample was made by collecting soil from several spots of the field at a depth of 0-15 cm before the initiation of the experiment. The collected soil was air-dried, ground and passed through 2 mm sieve and analyzed from some important physical and chemical parameters. Some initial physical and chemical characteristics of the soil are presented in Appendix II and III.

3.1.3. Climate

The experimental area has sub-tropical climate characterized by heavy rainfall during May to September and scanty rainfall during rest of the year. The annual precipitation of the site is 2152 mm and potential evapotranspiration is 1297 mm. The experiment

was carried out during rabi season of 2018-19. Air temperature during the cropping period ranged from 13.3^{0}C to 34.1°C. The relative humidity varied from 62.5% to 96.7% and monthly rainfall varied from 0.64 mm to 12.12 mm from the beginning of the experiment to harvest. The monthly maximum and minimum temperature, humidity and rainfall of the site during the experimental period are given in appendix IV, V and VI respectively.

3.2. Experimental materials

BARI Piaz-1 (winter) a BARI released cultivar of onion was used as experimental material. This onion variety is well recognized and mostly cultivated in different districts of Bangladesh. The variety has average plant height 50-55cm, number of leaves/plant 10-12, bulb type-single (non splitted) and flat, bulb color reddish brown, unit bulb weight 30-40 g, pungency, TSS 12-15%, storage capacity high, comparatively less infestation of pest and diseases, crop duration 130-140 days. This variety is capable of seed production in Bangladesh environment (Anonymous, 2000).

3.3. Raising of seedlings

For raising seedlings, the soil was ploughed and converted into loose friable and dried masses. All weeds, stubbles and dead roots were removed. Cowdung was applied to the prepared seed beds at the rate of 10 t/ha. The seeds were sown in the seed beds of 2.5m x lm size on 21 October 2018. After sowing, the seeds were covered with a thin layer of sandy soil. When the seeds germinated, shade by bamboo mat (Chatai) was provided to protect the young seedlings from scorching sun-shine and rain. Light watering, weeding and mulching were done as and when necessary. No chemical fertilizers were applied for raising the seedlings. Seedlings were not attacked by any kind of insects or diseases. Seed germination started at 25 October, 2018. The healthy

30 days old seedlings were transplanted in the experimental field on 21 November 2018.

3.4. Treatments of the experiment

The experiment consists of 2 factors i.e. different fertilizer doses and different mulching materials. Details of factors and their combinations are presented below:

Factor A: Different doses of Boron and Sulphur fertilizer

F_0: $S_{0kg}B_{0kg/ha}$ (Sulphur 0 kg/ha and Boron 0 kg/ha) Control

F_1: $S_{20kg}B_{1kg/ha}$ (Sulphur 20 kg/ha and Boron 1 kg/ha)

F_2: $S_{40kg}B_{2kg/ha}$ (Sulphur 40 kg/ha and Boron 2 kg/ha)

F_3: $S_{60kg}B_{3kg/ha}$ (Sulphur 60 kg/ha and Boron 3 kg/ha)

Factor B: Different mulching treatments

M_0: Control (No mulch and no irrigation)

M_1: Black polythene mulch

M_2: Water hyacinth mulch

M_3: Rice straw mulch

Treatment Combination

F_0M_0 = (No B, S and mulch materials)

F_0M_1 = (Black polythene with no B and S fertilizer)

F_0M_2 = (Water hyacinth with no B and S fertilizer)

F_0M_3 = (Rice straw with no B and S fertilizer)

F_1M_0 = (Sulphur 20 kg/ha and Boron 1 kg/ha with no mulch materials)

F_1M_1 = (Sulphur 20 kg/ha and Boron 1 kg/ha with Black polythene)

F_1M_2 = (Sulphur 20 kg/ha and Boron 1 kg/ha with Water hyacinth)

F_1M_2 = (Sulphur 20 kg/ha and Boron 1 kg/ha with Rice straw)

F_2M_0 = (Sulphur 40 kg/ha and Boron 2 kg/ha with no mulch materials)

F_2M_1 = (Sulphur 40 kg/ha and Boron 2 kg/ha with Black polythene)

F_2M_2 = (Sulphur 40 kg/ha and Boron 2 kg/ha with Water hyacinth)

F_2M_2 = (Sulphur 40 kg/ha and Boron 2 kg/ha with Rice straw)

F_3M_0 = (Sulphur 60 kg/ha and Boron 3 kg/ha with no mulch materials)

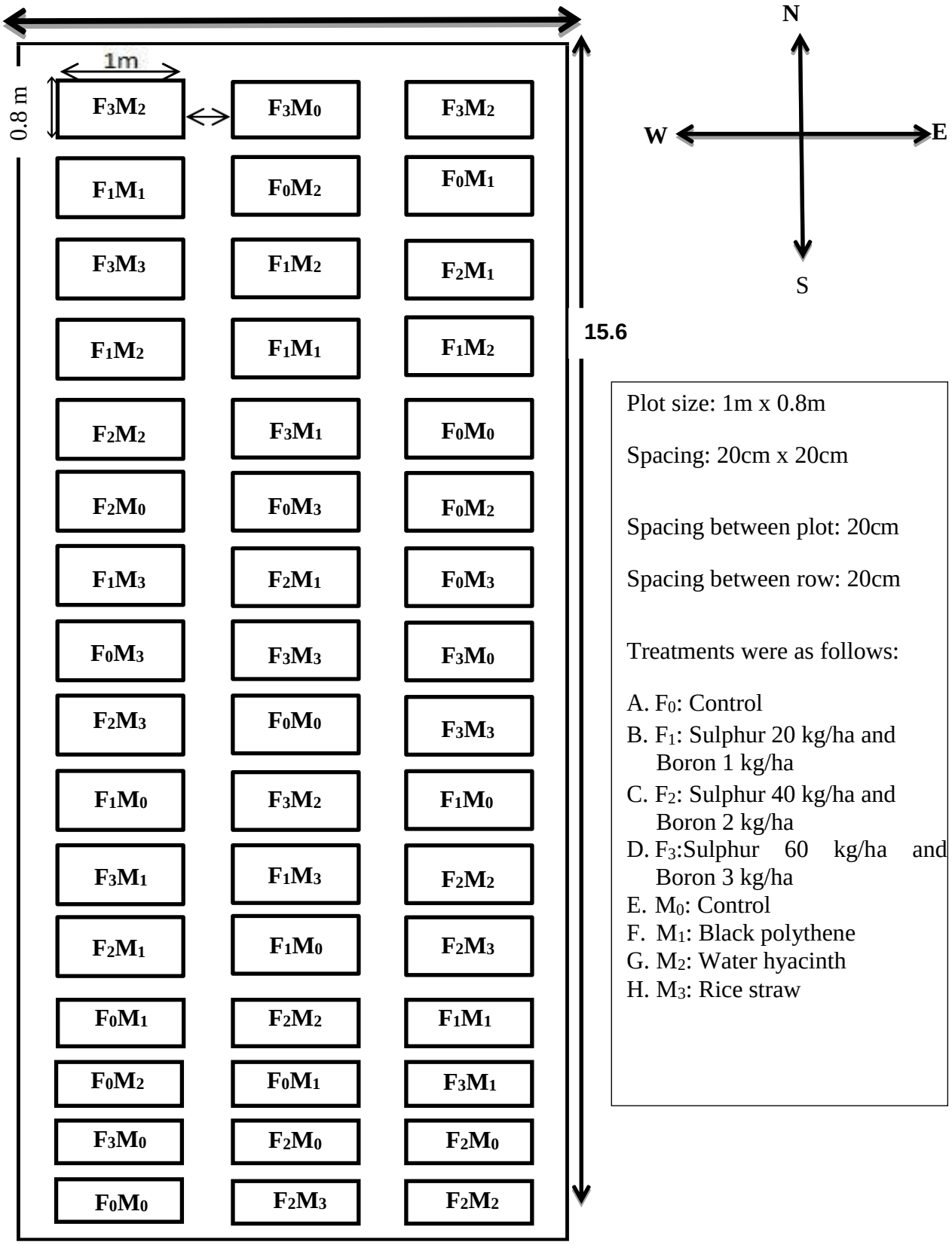
F_3M_1 = (Sulphur 60 kg/ha and Boron 3 kg/ha with Black polythene)

F_3M_2 = (Sulphur 60 kg/ha and Boron 3 kg/ha with Water hyacinth)

F_3M_2 = (Sulphur 60 kg/ha and Boron 3 kg/ha with Rice straw)

3.5. Design and layout of the experiment

The experiment consisted of 16 treatment combinations and was laid out in Randomized Complete Block Design (RCBD) with 3 replications. An area of 390 m^2 was divided into three equal blocks, representing the replications, each containing 16 plots. Thus, the total numbers of unit plots were 48. Each measuring 1 m x 0.8 m (0.8 m^2). The treatment combinations of the experiment were assigned at random into 16 plots of each at 3 replications. The distance retained between two plots was 20 cm and between blocks was 20 cm. The layout of the experiment is presented in Figure 1.



Plot size: 1m x 0.8m

Spacing: 20cm x 20cm

Spacing between plot: 20cm

Spacing between row: 20cm

Treatments were as follows:

A. F_0: Control
B. F_1: Sulphur 20 kg/ha and Boron 1 kg/ha
C. F_2: Sulphur 40 kg/ha and Boron 2 kg/ha
D. F_3:Sulphur 60 kg/ha and Boron 3 kg/ha
E. M_0: Control
F. M_1: Black polythene
G. M_2: Water hyacinth
H. M_3: Rice straw

Figure 1: Layout of the field experiment

3.6. Preparation of the field

The plot selected for the experiment was opened by a tractor on the 11th November 2018, afterwards the land was ploughed and cross-ploughed several times with the help of a power tiller followed by laddering to obtain a good tilth. Weeds and stubbles were removed, and the large clods were broken into smaller pieces to obtain a desirable tilth of friable soil for transplanting of seedlings. Finally, the land was leveled and the experimental plot was partitioned into the unit plots in accordance with the experimental design mentioned in the following section (3.5). Irrigation and drainage channels were prepared around the plots.

Plate 1. A pictorial view of seedbed preparation for raising of seedling

Plate 2. A pictorial view of raising of seedlings on seedbed

Plate 3. A pictorial view of experimental plot

Plate 4. A pictorial view of mulching with water hyacinth

Plate 5. A pictorial view of mulching with black polythene

Plate: A pictorial view of mulching with rice straw

Plate 7. A pictorial view of data collection

3.7. Rate of common doses of fertilizers and manures

In this experiment fertilizers and manures (except S and B fertilizers) were applied according to the recommendation rate of BARI which was as follows:

Common doses:

Table 1. The following doses of manures and fertilizers were applied in the experimental plots

Manures/Fertilizer	Dose/ha	Dose/plot
Well decomposed cowdung	10 ton	1 kg
Urea	150 kg	12 g
Triple Super Phosphate (TSP)	100 kg	8 g
Muriate of Potash (MP)	180 kg	15 g

Table 2. Nutrient content of different sources of manures and fertilizer

Sources of nutrients	Nutrient content of different manures and fertilizer		
	N_2%	P_2O_5%	K_2O%
Cowdung	0.43	0.35	0.21
Urea	46	-	-
TSP	-	48	-
MP	-	-	60

The whole amount of cowdung was applied during land preparation. Half of the recommended dose of urea, the whole amount of TSP and half of MP were applied during final land preparation and properly mixed with soil. The rest of urea and MP were applied as top dress at 25 days after transplanting along the rows where no mulch used.

3.8. Uprooting and transplanting of seedlings

Healthy and disease free uniform sized 30 days old seedlings were uprooted from the seedbeds and transplanted in the main field with the spacing of line to line 20 cm and plant to plant 20 cm in the afternoon on 21th November 2018. The seedbed was watered before uprooting the seedlings so as to minimize the damage of roots. The seedlings were watered immediately after transplanting. Some seedlings were also transplanted contiguous to the experimental field to be used for gap fillings.

3.9. Intercultural operation

After transplanting the seedlings, intercultural operations were done whenever required for getting better growth and development of the plants and so the plants were always kept under careful observation.

3.9.1. Gap fillings

Damaged seedlings were replaced by using healthy plants from the excess plants within one week.

3.9.2. Weeding and mulching

Weeding was done three times after transplanting to keep the crop free from weeds and mulching was done by breaking the crust of the soil for easy aeration and to conserve soil moisture when needed, especially after irrigation. Mulching was done on 20 November 2018 and hole was made with the help of blade and khurpi in case of black polythene. Also the water hyacinth and rice straw were used after transplanting.

3.9.3. Irrigation and drainage

The young seedlings in the field were irrigated just after transplanting. Irrigation was provided by a watering can and/or hose pump when needed throughout the growing time mainly after top dressing and after weeding. At this time care was taken so that irrigated water could not pass from one plot to another. During each irrigation, the soil was made saturated with water. After rainfall, excess water was drained when necessary.

3.9.4. Protection of plants

Against the soil born insect preventive measure was taken. For the prevention of Cutworm (*Agrotis ipsilon*). soil treatment was done with Furadan 3 G @ 20 kg ha^{-1}. Few days after transplanting, some plants were attacked by purple blotch disease caused by *Alternaria porri,* it was controlled by spraying Rovral 50 WP two times at 15 days interval after transplanting.

3.10. Harvesting

The crop was harvested on 13 March 2019 when 75% of the tops in each plot had fallen over (Shalaby *et al.,* 1991). Generally the maturity symptom indicated by 75-80% of leaf senescence and drying out of the top. The tops of onion were removed by cutting off the pseudostem keeping 2.5 cm with the bulb.

3.11. Methods of data collection

The data pertaining to the following characters were recorded from ten (10) plants randomly selected from each unit plot such a way that the border effect could be avoided. Data on plant height and leaf no. were collected at 15, 30, 45 and 60 days after transplanting and also at harvest. All other parameters were recorded at harvest. Data on the above mentioned crop characters were as follows:

3.11.1. Plant height (cm)

The plant height was measured in centimeters from the base of plant to the terminal growth point of main stem on tagged plants at 15 days, interval starting from 15 days of planting up to 60 days to observe the plant height. The average height was computed and expressed in centimeter.

3.11.2. Number of leaves per plant

The number of leaves per plant was manually counted at 15, 30, 45 and 60 days after transplanting from randomly selected plants. The average of ten plants were computed and expressed in average number of leaves per plant.

3.11.3. Bulb length per plant (cm)

Length of harvested bulbs was measured with a slide calipers from the neck to the bottom of the bulb from live randomly selected plants and their average was taken.

3.11.4. Bulb diameter (cm)

Diameter of the harvested bulb was measured with a slide calipers at the middle portion of ten randomly selected plants from each plot and their average was calculated and expressed in cm.

3.11.5. Neck diameter (cm)

Diameter of the harvested bulb neck was measured with a slide calipers at the tip portion of bulb from ten selected plants from each plot and their average was calculated and expressed in cm.

3.11.6. Dry matter content of bulb (%)

A sample of 100 g of leaves was collected and dried under direct sunshine for 48 hours and then dried in an oven at 70^0C for 3 days. After oven drying, bulbs were weighed. The dry weight was recorded in gram (g) with an electric balance. The percentage of dry matter was calculated by the following formula:

$$\text{Percent of bulb dry matter} = \frac{\text{Weight of dry materials}}{\text{Fresh weight of bulb}} \times 100$$

3.11.7. Fresh weight of leaves per plant (g)

The fresh weight of leaves per plant was recorded from the average of 5 plants selected from each plot.

3.11.8. 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:

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

3.11.9. Root length

Root length was measured with a centimeter scale from the base to the tip of the longest root at harvest and their average was taken as the root length in centimeter.

3.11.10. Weight of single bulb (g)

Ten plants were randomly selected from each unit plot. The bulbs were weighted by a simple balance and the average was calculated and expressed in gram.

3.11.11. Yield per plot (kg)

All the leaves along with pseudo stem were removed keeping only 2.5 cm neck. The weight of the bulb was taken by an electric balance in kilograms (kg) from each unit plot separately.

3.11.12. Yield (ton/hectare)

The yield of bulb per plot was converted into ton per hectare to get the yield of onion.

$$\text{Crop yield (t/ha)} = \frac{\text{Crop yield per plot (kg) x 1000}}{\text{Area of plot in } m^2 \text{ x 10000}}$$

3.12. Statistical analysis

The data obtained from the experiment were analyzed statistically using MSTAT computer package program to find out the significance of the difference among the treatments. The mean values of all the treatment were calculated and analysis of variances for all the characters was performed by the Ft (variance ratio) test. The signilicance of the differences among the pairs of treatment means was estimated by the Duncan Multiple Range Test (DMRT) at 5% level of probability (Gornez and Gomez 1984) for the interpretation of results.

CHAPTER IV

RESULTS AND DISCUSSION

The results of the growth and yield of onion as influenced by sulphur and boron with mulch materials have been presented and discussed in this chapter. The analysis of variance (ANOVA) of data on different growth and yield parameters are presented in the Appendices VII-XII. The results of the study have been presented and discusses with the help of table and graphs and possible interpretations given under the following sub-headings.

4.1. Plant height (cm)

The result showed significant differences on plant height with the application of different levels of sulphur and boron fertilizers combination at 15, 30, 45 and 60 day after transplanting (DAT) of onion plants (Fig. No. 2). At 15 DAT, the highest plant height (18.56 cm) was recorded from the F_3 ($S_{60kg/ha}$ and $B_{3kg/ha}$) treatment. At 30 DAT, the longest plant height (28.70 cm) of onion was recorded from the treatment of F_3 and shortest plant height (23.81 cm) was obtained from the treatment F_0 (control). At 45 DAT, similarly the longest plant height (39.35 cm) was recorded from the F_3 treatment while, the shortest plant height (33.66 cm) was found from the F_0 treatment. At 60 DAT, the highest plant height (53.38 cm) was recorded from the F_3 treatment while, the shortest plant height (47.88 cm) was observed from the F_0 (control) treatment. The plant height increases with the progress of plant growth. This might be due to the fact that fertilizers supplied adequate plant nutrients for better vegetative growth of the plants which ultimately increased plant height. Similar results also reported by Paul *et al.* (2007). They found that application of 60 kg sulphur/ha and 3 kg boron/ha produced the tallest plants (48.48 cm) at 60 DAT.

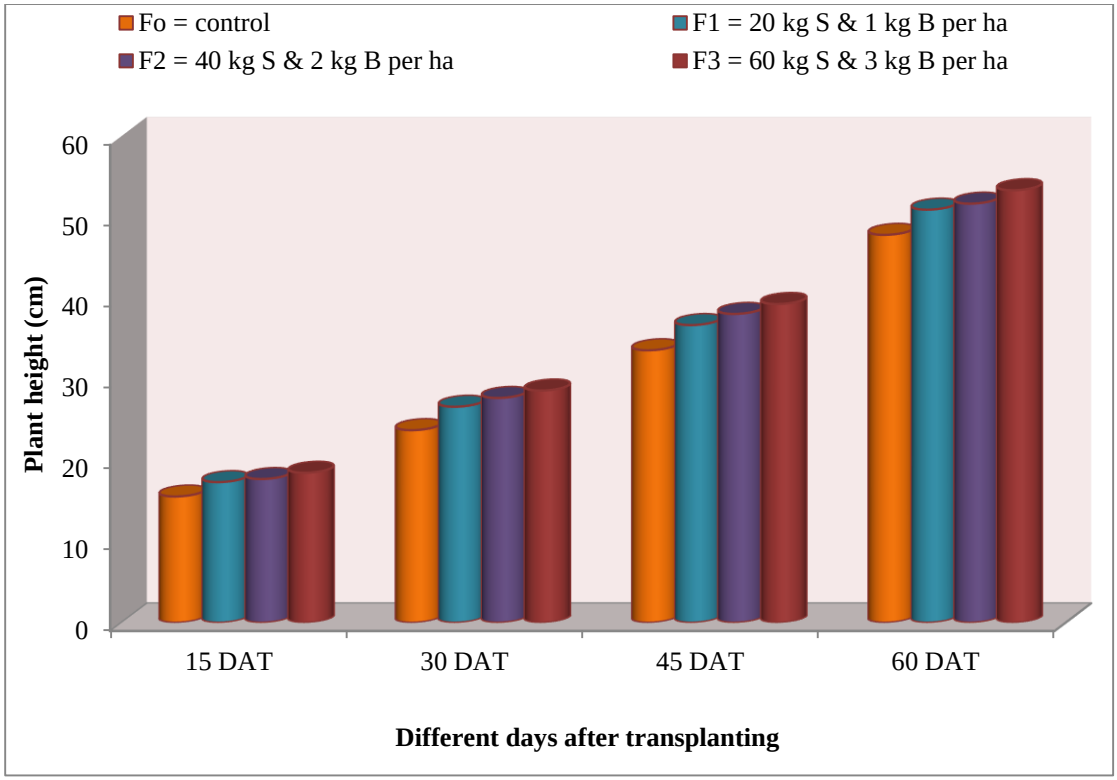


Fig. 2. Effect of S and B on plant height of onion at different days after transplanting (DAT)

Many previous reports showed that mulching conserves soil moisture as well as provides desirable soil temperature thus promotes the vegetative growth of plant including onion plant height (Stowell, 2000; Mahajan *et al.*, 2007). Significance difference was found due to mulching on the plant height at 15, 30, 45 and 60 DAT (Figure 3). At 15 DAT, the longest plant height (18.23 cm) was recorded from the treatment M_1 (black polythene) which is statistically similar with M_0, M_2, M_3 treatments (Figure 3). At 30 DAT, the longest plant height (27.96 cm) was recorded from the treatment M_1 while the shortest plant height (24.75 cm) from M_0 (no mulch) treatment. At 45 DAT, the longest plant height (38.88 cm) was recorded from the treatment M_1 which was statistically similar with M_2 (37.69) (water hyacinth) while, the shortest plant height (34.99 cm) from M_0 treatment. At 60 DAT, the highest plant height (52.51 cm) was recorded from M_1 treatment, while the shortest plant height

(48.85 cm) from M_0 treatment. The effect of mulches might be accounted for conserving sufficient soil moisture providing water to plants at stages of growth and keeping the soil warm resulting increased height of plant. On the contrary, without mulch, plant suffered from water stress and could not accomplish potential vegetative growth. These results have the similarity with the previous reports of Suh *et al.* (1991) they reported that the increase in plant heights due to various mulches in onion. Similar result also found from Akter (2017). Where she found that black polythene mulch increased plant height over control.

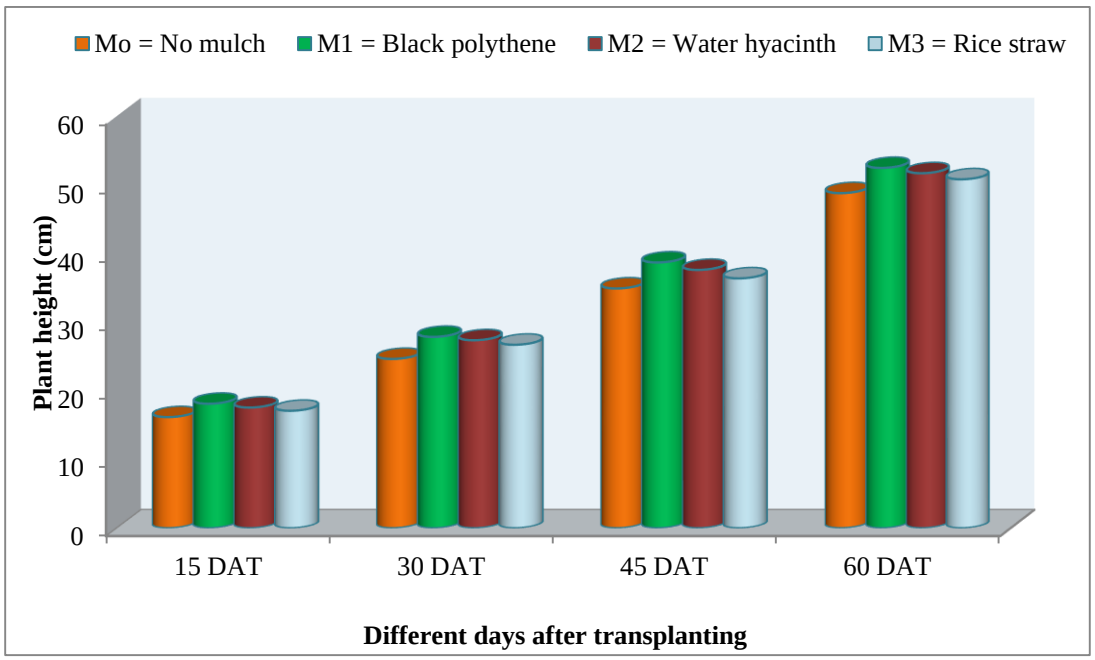


Fig. No. 3. Effect of different mulch materials on plant height of onion at different days after transplanting (DAT)

Combined effect of sulphur and boron with different mulch materials also showed significant difference on the plant height of onion at 30, 45 and 60 DAT (Table 3). At 30 DAT, the longest plant height (29.92 cm) was recorded from the F_3M_1 ($S_{60kg/ha}$ and $B_{3kg/ha}$ with black polythene mulch) treatment while, the shortest plant height (22.67 cm) from F_oM_o treatment. Similarly, at 45 DAT, the longest plant height (41.00 cm) was recorded from the F_3M_1 treatment while, the shortest plant height (31.29 cm)

from F_oM_o treatment. At 60 DAT, the longest plant height (55.54 cm) was recorded from F_3M_1 treatment combination while, the shortest plant height (47.13 cm) from F_oM_o treatment combination. In this study sulphur 60 kg/ha, boron 3 kg/ha with black polythene mulch possibly maintained higher moisture content and more uniform temperature distribution in soil making more nutrient elements available for increasing plant growth.

Table 3. Combined effect of sulpher and boron fertilizers with mulch materials on plant height of onion at different days after transplanting (DAT)

Treatments	Plant height (cm) at different days after transplanting (DAT)			
	15 DAT	30 DAT	45 DAT	60 DAT
F_oM_o	14.16	22.67 k	31.29 m	47.13 j
F_oM_1	16.80	24.83 i	36.00 ij	48.79 gh
F_oM_2	15.99	23.92 j	35.04 k	47.92 i
F_oM_3	15.55	23.83 jk	32.29 l	47.67 ij
F_1M_o	16.74	24.75 ij	35.75 jk	48.67 h
F_1M_1	17.85	28.00 d	37.79 ef	52.71 cd
F_1M_2	17.61	27.42 e	36.88 g	51.75 de
F_1M_3	17.41	26.63 f	36.62 h	50.79 e
F_2M_o	16.87	25.54 h	36.38 i	49.04 fg
F_2M_1	18.69	29.08 b	40.29 b	53.00 bc
F_2M_2	17.93	28.67 c	38.21 d	52.71 cd
F_2M_3	17.65	27.83 de	37.67 fg	52.13 d
F_3M_o	17.33	26.04 g	36.54 hi	50.55 ef
F_3M_1	19.58	29.92 a	41.00 a	55.54 a
F_3M_2	19.16	29.88 ab	40.63 b	54.58 b
F_3M_3	18.18	28.96 bc	39.25 c	52.83 cd
CV %	9.16	11.97	11.68	12.58
LSD (0.05)	---	0.48	0.32	0.42

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[F_0 - Control, F_1 - ($S_{20kg/ha}$ and $B_{1kg/ha}$), F_2 - ($S_{40kg/ha}$ and $B_{2kg/ha}$), F_3 - ($S_{60kg/ha}$ and $B_{3kg/ha}$), M_0 – No mulch and no irrigation, M_1 - Black polythene, M_2 - Water hyacinth, M_3 - Rice straw]

4.2. Number of leaves per plant

Significant variation was observed in the average no. of leaves per plant due to the effect of different combination of sulphur and boron fertilizer at different growth stage like 15, 30, 45 and 60 DAT (Fig. No. 4). At 15 DAT, the highest leaves per plant (2.94) was recorded from the F_3 ($S_{60kg/ha}$ and $B_{3kg/ha}$) treatment and the lowest number of leaves (2.44) found from the F_0 (control) treatment. At 30 DAT, the highest leaves per plant (6.26) was recorded from the F_3 treatment which was statistically different from other treatments and the lowest number of leaves (4.06) was found from the F_0 treatment. At 45 DAT the highest leaves per plant (8.27) was recorded from the F_3 treatment which was also statistically different from other treatments and the lowest number of leaves (5.35) was found from the F_0 treatment. Similarly, at 60 DAT, the maximum leaves per plant (10.48) was recorded from the F_3 treatment and the minimum number of leaves (7.45) was found from the treatment F_0. The leaf production ability of the plant was greatly influenced by the application of sulphur and boron combination. Similar results also reported by Paul *et al.* (2007). They found that the number of leaves per plant measured at 60 DAT was the highest (6.49) from 3 kg B/ha and the lowest number of leaves per plant (6.18) was found from the control. Application of sulphur up to 60 kg/ha resulted in a gradual increase in the number of leaves per plant. The maximum number of leaves per plant (6.77) was recorded in the combination of 3 kg B and 60 kg S/ha at 60 DAT.

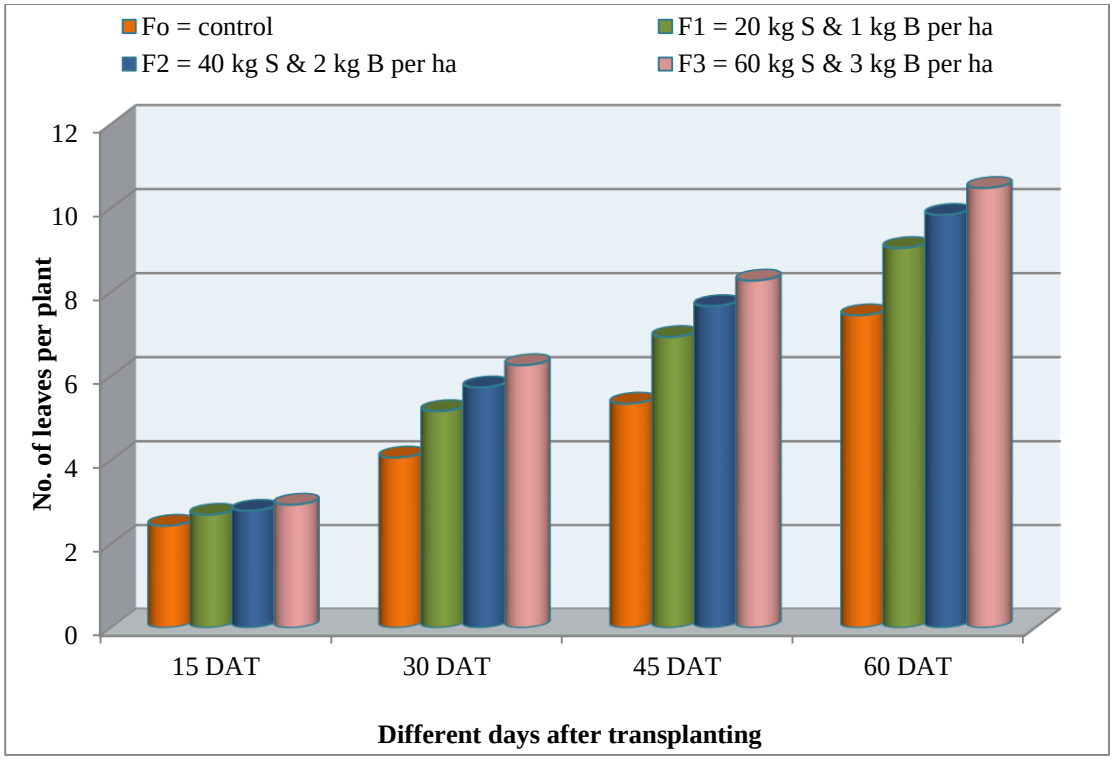


Fig. No. 4. Effect of S and B on number of leaves per plant at different days after transplanting (DAT)

Number of leaves per plant of onion was significantly influenced by the application of different mulch materials at 15, 30, 45 and 60 DAT (Appendix III). At 15 DAT, the highest number of leaves (2.85) was recorded from the M_1 (Black polythene) treatment and the lowest no. of leaves per plant 2.51 was recorded in the treatment of M_0 (no mulch) (fig. No. 5). At 30, 45, 60 DAT, the maximum number of leaves per plant (respectively 5.98, 7.97 and 10.19) was recorded from the M_1 treatment which was statistically different from other treatments. On the other hand, the minimum number of leaves per plant (4.44, 5.77, and 7.93) was recorded from the M_0 treatment at 30, 45 and 60 DAT, respectively. Temperature and moisture of the soil are the two important factors affecting the number of leaves. Mulch treated plants, produced greater number of leaves, which might be due to the optimum soil temperature and higher soil moisture preserved at root zone during the whole growing period. In

control plots moisture stress continued. Azam (2005) also found the similar result. He found that black polythene gave the highest number of leaves (7.03) of onion compared to other mulches.

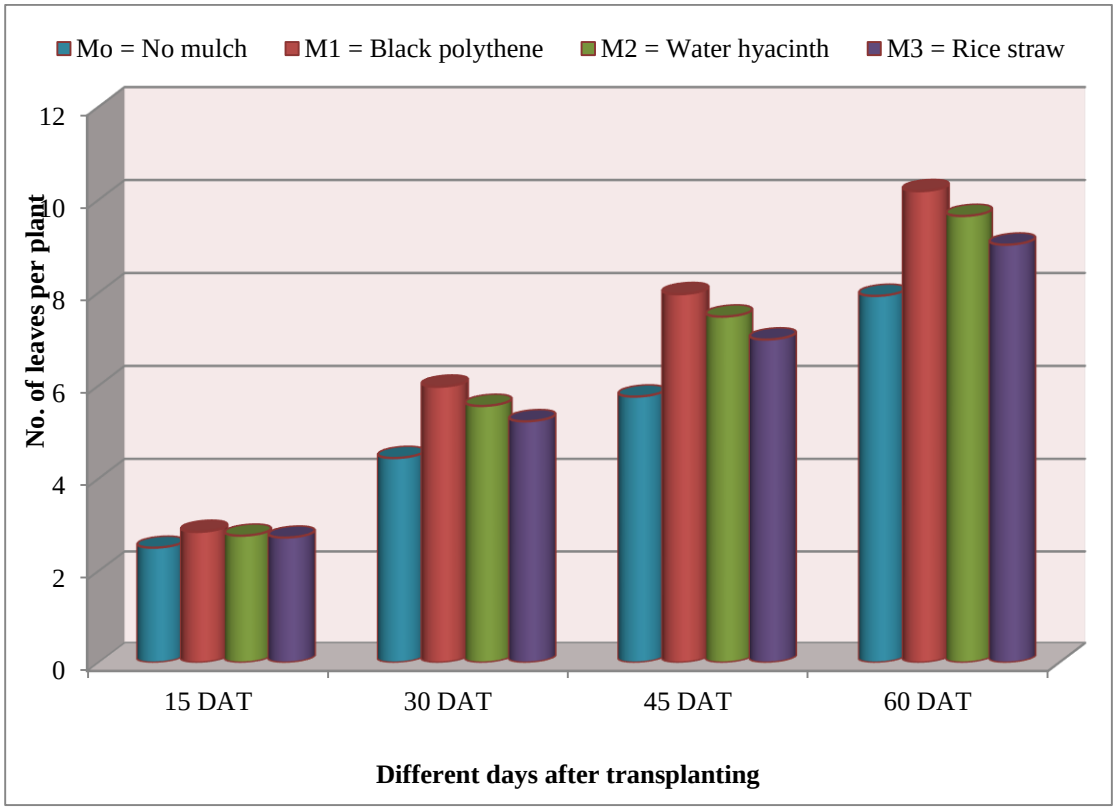


Fig. No. 5. Effect of different mulches on number of leaves per plant at different days after transplanting (DAT)

Combined effect of sulphur and boron combination with different mulch materials also showed significant difference on the number of leaves at 30, 45 and 60 DAT (Table 4). At 30 DAT, the highest number of leaves per plant of onion (7.12) was recorded from the F_3M_1 ($S_{60kg/ha}$ and $B_{3kg/ha}$ with black polythene mulch) treatment which was statistically different from all other treatments. The lowest number of leaves per plant (3.84) was observed from the F_oM_o (control) treatment which was statistically similar with the treatment F_oM_3. At 45 DAT, the highest number of leaves per plant (9.22) was recorded from the F_3M_1 treatment, which was statistically different from all other treatments and the lowest number of leaves per plant (4.92)

from the F_oM_o treatment. At 60 DAT, the maximum number of leaves per plant (11.47) was recorded from the treatment combination of F_3M_1, which was statistically similar (11.33) to the F_3M_2 ($S_{60kg/ha}$ and $B_{3kg/ha}$ with water hyacinth mulch) followed by F_2M_o (11.03) treatment combination. Similarly, the minimum number of leaves per plant (6.90) was observed from F_oM_o treatment combination.

Table 4. Combined effect of sulpher and boron application with different mulch materials on number of leaves per onion plant at different days after transplanting (DAT)

Treatments	Number of leaves at different days after transplanting (DAT)			
	15 DAT	30 DAT	45 DAT	60 DAT
F_oM_o	2.24	3.84 o	4.92 p	6.90 n
F_oM_1	2.58	4.49 l	5.95 l	8.09 j
F_oM_2	2.46	4.02 n	5.36 n	7.61 l
F_oM_3	2.46	3.91 no	5.15 o	7.19 m
F_1M_o	2.54	4.31 m	5.61 m	7.88 k
F_1M_1	2.79	5.79 f	7.84 f	10.17 d
F_1M_2	2.75	5.38 h	7.31 h	9.21 f
F_1M_3	2.71	5.18 i	6.97 i	8.94 g
F_2M_o	2.58	4.72 k	6.20 k	8.38 i
F_2M_1	2.96	6.51 c	8.86 c	11.03 b
F_2M_2	2.83	6.08 e	8.18 e	10.47 c
F_2M_3	2.79	5.61 g	7.43 g	9.47 e
F_3M_o	2.67	4.91 j	6.34 j	8.57 h
F_3M_1	3.08	7.12 a	9.22 a	11.47 a
F_3M_2	3.04	6.78 b	9.10 b	11.33 a
F_3M_3	2.96	6.23 d	8.43 d	10.54 c
CV %	8.41	9.67	9.25	10.98
LSD (0.05)	---	0.14	0.11	0.17

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[F_0 - Control, F_1 - ($S_{20kg/ha}$ and $B_{1kg/ha}$), F_2 - ($S_{40kg/ha}$ and $B_{2kg/ha}$), F_3 - ($S_{60kg/ha}$ and $B_{3kg/ha}$), M_0 - No mulch and no irrigation, M_1 - Black polythene, M_2 - Water hyacinth, M_3 - Rice straw]

The present finding is in agreement with the report of Smriti *et al.* (2002). Such response may be accounted for the physiochemical and biological improvement occurred in the including favorable temperature and moisture regimes, nutrient availability and microbial activity that mulching might have provided.

4.3. Bulb length (cm)

The effect of different combination of S and B treatments on the bulb length per plant of onion was found to be significant at harvest (Table 5). The maximum bulb length (4.83 cm) was found from the F_3 ($S_{60kg/ha}$ + $B_{3kg/ha}$) treatment and which was statistically different all other treatments. The minimum bulb length (2.62 cm) was recorded from the control F_o (control) treatment.

The effect of different mulching treatments on the bulb length of onion per plant was found to be significant at harvest (Table 6). The highest bulb length (4.52 cm) was recorded from the treatment of M_1 (black polythene mulch). Whereas the lowest bulb length (2.99 cm) was obtained from control (M_0) treatments. It might be due to the retention of adequate soil moisture, conserved properly by the black polythene mulch, which subsequently helped in the formation of highest length of bulb.

Combined effect of sulphur and boron combination with application of different mulch materials also showed significant difference in case of bulb length (Table 7). The longest bulb length (5.51 cm) was found from the treatment of F_3M_1 ($S_{60kg/ha}$ and $B_{3kg/ha}$ with black polythene mulch). And the shortest bulb length (2.25 cm) was found from the F_oM_o ($S_{0kg/ha}$ and $B_{0kg/ha}$ with no mulch and no irrigation) treatment combination.

4.4. Bulb diameter (cm)

The variation in diameter of bulb due to different doses of sulphur and boron combination treatments was found statistically significant (Table 5). The maximum bulb diameter (6.00 cm) was found from the F_3 ($S_{60kg/ha}$ + $B_{3kg/ha}$) treatment and the minimum bulb diameter (3.98 cm) was recorded from the F_o (control) treatment. All the treatments were statistically different from each other. This may be due to production of maximum diameter of bulb by S and B application which accumulated more carbohydrates in bulb which was reported by the Nasreen *et al.* (2009). Similar result was also found by Paul *et al.,* (2007), where highest diameter of bulb (4.32 cm) was obtained from the combine effect of 30 kg sulphur and one kg boron per hectare.

Mulching conserve soil moisture and regulate soil temperature thus induce rapid growth of onion plant and proper development of onion bulb resulting in higher bulb diameter (Jamil *et al.,* 2005). In this study showed that mulching had significant effect on diameter of onion bulb (Table 6). The highest bulb diameter (5.74 cm) was recorded with treatment of M_1 (black polythene mulch). Whereas the lowest bulb diameter (4.33 cm) was obtained from control (M_0) treatments. Akter (2017) stated similar result by using mulch materials. He observed that application of black polythene mulch produce highest bulb diameter compared to other mulches.

Combined effect of sulphur and boron with different mulch materials also showed significant difference on the diameter of onion bulb (Table 7). The highest bulb diameter (6.68 cm) was recorded with F_3M_1 ($S_{60kg/ha}$ and $B_{3kg/ha}$ with black polythene mulch) treatment which was statistically similar with F_3M_2 (6.44 cm) treatment. On the other hand, the lowest bulb diameter (3.67 cm) was obtained from F_oM_o treatment which was statistically similar to F_oM_3 (3.85) treatment combination.

4.5. Neck diameter (cm)

Non-significant variation was observed in diameter of neck among the different combination of sulphur and boron treatments (Table 5). The maximum neck diameter (1.31 cm) was obtained from F_3 ($S_{60kg/ha}$ + $B_{3kg/ha}$) treatment, whereas the minimum neck diameter (1.09 cm) was recorded from control F_o (control) treatment.

No significant effect on neck diameter was observed with the mulching treatments (Table 6). The maximum neck diameter (1.26 cm) was obtained from M_1 (black polythene mulch) treatment, whereas the minimum neck diameter (1.13 cm) was recorded from M_0 (no mulch and no irrigation) treatment.

The combined effect of S and B with mulch was also found to be statistically non significant in this respect (Table 7). Maximum neck diameter of bulb (1.42 cm) was obtained from the F_3M_1($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) treatment and minimum diameter of neck (1.03 cm) found from the combination of F_oM_o treatment.

4.6. Root length (cm)

A Significant variation in root length was found with the application of different levels of S and B combination (Table 5). The longest root length (7.78 cm) was found from the treatment F_3 ($S_{60kg/ha}$ + $B_{3kg/ha}$) whereas the shortest root length (6.29 cm) was found from treatment F_0 of (control).

The variation in root length among the different mulching materials was found statistically significant (Table 6). The longest root length (7.39 cm) was found from the M_1 (black polythene) treatment. On the other hand, the non mulch controlled M_0 produced the shortest root length of 6.95 cm.

The effect of combined application of S and B nutrients combinations with different levels of mulching materials on root length of onion plants was found significant (Table 7). The longest root length (7.90 cm) was found from the treatment of F_3M_o

which was statistically similar to F_3M_2 (7.83). On the other hand, the shortest root length (5.97 cm) was found from the F_oM_1 treatment which was statistically similar with F_oM_3 (6.08 cm) and F_oM_2 (6.33 cm) treatment.

Table 5. Effect of sulphur and boron fertilizer on the bulb length, bulb diameter, neck diameter and root length of onion

Treatments	Bulb length (cm)	Bulb diameter (cm)	Neck diameter (cm)	Root length (cm)
F_o	2.62 d	3.98 d	1.09	6.29 d
F_1	3.78 c	5.01 c	1.16	7.11 c
F_2	4.32 b	5.52 b	1.24	7.49 b
F_3	4.83 a	6.00 a	1.31	7.78 a
CV %	11.45	10.62	8.66	11.87
LSD (0.05)	0.137	0.119	---	0.25

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[F_0 - Control, F_1 - ($S_{20kg/ha}$ and $B_{1kg/ha}$), F_2 - ($S_{40kg/ha}$ and $B_{2kg/ha}$), F_3 - ($S_{60kg/ha}$ and $B_{3kg/ha}$)].

Table 6. Effect of mulch materials on the bulb length, bulb diameter, neck diameter and root length of onion

Treatments	Bulb length (cm)	Bulb diameter (cm)	Neck diameter (cm)	Root length (cm)
M_o	2.99 d	4.33 d	1.13	6.95 c
M_1	4.52 a	5.74 a	1.26	7.39 a
M_2	4.16 b	5.36 b	1.22	7.21 b
M_3	3.88 c	5.09 c	1.18	7.10 b
CV %	11.45	10.62	8.66	11.87
LSD (0.05)	0.1622	0.134	---	0.14

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[M_0 – No mulch, M_1 - Black polythene, M_2 - Water hyacinth, M_3 - Rice straw].

Table 7. Combined effect of S and B fertilizer with different mulch materials on the bulb length, bulb diameter, neck diameter and root length of onion

Treatments	Bulb length (cm)	Bulb diameter (cm)	Neck diameter (cm)	Root length (cm)
F_oM_o	2.25 o	3.67 n	1.03	6.77 fg
F_oM_1	3.04 k	4.40 jk	1.12	5.97 h
F_oM_2	2.68 m	4.01 lm	1.10	6.33 gh
F_oM_3	2.49 n	3.85 mn	1.10	6.08 h
F_1M_o	2.81 l	4.21 kl	1.11	7.30 cde
F_1M_1	4.50 e	5.62 de	1.20	6.86 ef
F_1M_2	4.02 g	5.18 fg	1.19	7.15 def
F_1M_3	3.80 h	5.03 gh	1.15	7.11 def
F_2M_o	3.31 j	4.62 ij	1.17	7.58 cd
F_2M_1	5.03 c	6.26 bc	1.31	7.37 bcd
F_2M_2	4.73 d	5.81 d	1.23	7.55 cd
F_2M_3	4.23 f	5.39 ef	1.22	7.44 cd
F_3M_o	3.61 i	4.83 hi	1.19	7.90 a
F_3M_1	5.51 a	6.68 a	1.42	7.61 cd
F_3M_2	5.21 b	6.44 ab	1.37	7.83 ab
F_3M_3	4.99 c	6.07 c	1.25	7.74 bc
CV %	11.45	10.62	8.66	11.87
LSD (0.05)	0.124	0.239	---	0.50

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[F_0 - Control, F_1 - ($S_{20kg/ha}$ and $B_{1kg/ha}$), F_2 - ($S_{40kg/ha}$ and $B_{2kg/ha}$), F_3 - ($S_{60kg/ha}$ and $B_{3kg/ha}$), M_0 - No mulch and no irrigation, M_1 - Black polythene, M_2 - Water hyacinth, M_3 - Rice straw]

4.7. Dry matter content of bulb (%)

Percent dry matter content of bulb significantly influenced by effect of different combination of sulphur and boron treatments (Table 8). The highest dry matter content (15.98%) was found from F_3 ($S_{60kg/ha}$ + $B_{3kg/ha}$) treatment and the lowest dry matter content (11.26%) was recorded from F_0 (control) treatment.

Rate of photosynthesis increased with the increase level of chlorophyll content. For this reason higher amount of dry matter was accumulated in onion bulb. Mulching had significant effect on dry matter content of bulb (Table 9). The highest dry matter content (15.49%) was found from the M_1 (black polythene mulch) treatment followed by the treatment of M_2 (14.53%) (water hyacinth). And lowest dry matter content (11.86%) was recorded from the M_0 (no mulch) treatment. Akram (2017) observed the same result that black polythene mulch gave the highest day matter content of bulb compared with water hyacinth and straw mulch.

Percent dry matter content of bulb was greatly influenced by the combined application of sulphur and boron with different mulch materials (Table 10). The highest dry matter content (17.62%) was found from the F_3M_1 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) treatment combination whereas lowest dry matter content (10.52%) was found from the treatment F_oM_o. It can be noted that the available soil nutrients supported proper vegetative growth by producing bulb with more protoplasm in the cells in comparison to less available nutrient in onion. On the other hand, when nutrient availability become reduce in the soil, decreased plant growth which causes less percent dry matter content in the onion bulb.

4.8. Leaf fresh weight (g)

The application of different combination of sulphur and boron treatments had significant influence on the fresh weight of leaves per plant of onion at all stages (Table 8). The plants grown under S 60 kg per ha + B 3 kg per ha (F_3) treatment gave maximum leaf fresh weight (26.82 g/plant) followed by S 40 kg/ha and B 2 kg/ha (F_2) (25.09 g/plant), S 20 kg/ha and B 1 kg/ha (F_1) (21.87 g/plant). The minimum fresh weight (17.15 g/plant) of leaves was found in control treatment.

The application of different levels of mulch also significantly influenced the fresh weight of leaves per plant (Table 9). The plants grown under black polythene mulch (M_1) treatment gave the maximum fresh weight (25.61 g/plant) of leaves followed by water hyacinth (M_2) (23.76 g/plant), rice straw (M_3) (22.69 g/plant). The minimum fresh weight (18.86 g/plant) of leaves was found in control treatment.

Fresh leaves weight was greatly influenced by the combination of sulphur and boron with application of different mulch materials (Table 10). The highest fresh leaf weight (29.30 g/plant) was found from the F_3M_1 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) treatment which was followed by F_3M_2 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with water hyacinth mulch) whereas lowest fresh weight (15.16 gm/plant) of leaf was found from the F_oM_o treatment.

4.9. Dry matter content of leaf (%)

The effect of S and B fertilizers was found to be statistically significant on the dry matter content of leaf (Table 8). The plants grown under F_3 ($S_{60kg/ha}$ + $B_{3kg/ha}$) treatment gave maximum dry matter content of leaf (24.74 %) followed by F_2 treatment. The minimum dry matter content (15.02 %) of leaves was found in control treatment.

The content of dry matter in leaf was significantly influenced by the different types of mulch (Table 9). The plants grown under black polythene (M_1) treatment gave maximum dry matter content of leaf (23.35%) followed by water hyacinth M_2 (21.68%), rice straw M_3 (20.40%) mulch treatments respectively. The minimum drymatter content (17.38%) of leaves was found in control treatment (Table 12). Similar result was found in a study carried out by Azom (2005). He found that the plants grown under black polythene mulch gave maximum leaf dry weight (10.38 %) compared to transparent polythene, rice straw mulch and saw dust mulch.

Dry matter content of leaf (%) was greatly influenced by the application of S and B combination with different mulch materials (Table 10). The highest dry matter content of leaf (27.48 %) was found from the F_3M_1 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) treatment which was followed by F_3M_2 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with water hyacinth mulch) whereas lowest dry matter content of leaf (13.42%) was found from the treatment of F_oM_o.

4.10. Individual bulb weight (g)

From the present research work, it was observed that there was significant variation among the treatments in respect of fresh weight of onion bulb due to different combinaiton of sulphur and boron treatment application (Table 8). The maximum bulb weight (39.93 g) was obtained from F_3 ($S_{60kg/ha}$ + $B_{3kg/ha}$) whereas lowest bulb weight (31.05 g) was obtained from the F_0 (control). From the above result, it was noted that combined used of S and B increased nutrient availability to plants and much bulb formation was occurred. The available soil nutrients supported proper vegetative growth by producing succulent bulb with more protoplasm in the cells in comparison to less available nutrients in onion. Paul *et al.* (2007) also found that combine effect of 1 kg B and 30 kg S/ha produced large onion bulb (24.53 g) compared to other treatments.

The application of different mulch materials also significantly influenced the individual bulb weight of onion (Table 9). The highest weight of individual bulb (39.05 g) was found from the M_1 (black polythene mulch) treatment followed by the water hyacinth M_2 (36.78 g) treatment. On the other hand, the lowest bulb weight (32.93 g) was obtained from M_0 (control) treatment. In case of black polythene mulch, plants get sufficient moisture and higher temperature. Probably that is why maximum bulb weight per plant was occurred in case of black polythene mulch. The mulching

favors the reduction of evaporation leading to higher soil moisture content, a reduction in weed growth and the decomposition of added mulches might have also contributed to increase the supply of nutrients and moisture for overall increase in crop yields (Vander Zaag *et al.*, 1986). Similar result was also found in a study carried out by Akter (2017). She found that mulching had significant effect on the single bulb weight. She also found that highest bulb weight was found when the plant grown in black polythene mulch.

Weight of single bulb was greatly influenced by the combination of S and B with different mulch materials treatment (Table 10). The highest single bulb weight (42.40 g) was found from the treatment combination F_3M_1 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) whereas the lowest single bulb weight (28.40 g) found from the F_oM_o treatment.

Table 8. Effect of sulphur and boron fertilizer on percent dry matter content of bulb (%), weight (g) of fresh leaf, dry matter content of leaf (%) and weight (g) of individual bulb

Treatments	Percent of dry matter content of bulb (%)	Fresh weight of leaves per plant (g)	Dry matter content of leaf (%)	Individual bulb weight (g)
F_o	11.26 d	17.15 d	15.02 d	31.05 d
F_1	13.51 c	21.87 c	20.39 c	35.50 c
F_2	14.88 b	25.09 b	22.66 b	37.95 b
F_3	15.98 a	26.82 a	24.74 a	39.93 a
CV %	9.54	10.27	7.56	13.37
LSD (0.05)	0.65	0.45	0.85	1.16

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[F_0 - Control, F_1 - ($S_{20kg/ha}$ and $B_{1kg/ha}$), F_2 - ($S_{40kg/ha}$ and $B_{2kg/ha}$), F_3 - ($S_{60kg/ha}$ and $B_{3kg/ha}$)].

Table 9. Effect of mulch materials on the bulb (%), weight (g) of fresh leaf, dry matter content of leaf (%) and weight (g) of individual bulb

Treatments	Percent of dry matter content of bulb (%)	Fresh weight of leaves per plant (g)	Dry matter content of leaf (%)	Individual bulb weight (g)
M_o	11.86 d	18.86 d	17.38 d	32.93 d
M_1	15.49 a	25.61 a	23.35 a	39.05 a
M_2	14.53 b	23.76 b	21.68 b	36.78 b
M_3	13.75 c	22.69 c	20.40 c	35.67 c
CV %	9.54	10.27	7.56	13.37
LSD (0.05)	0.49	0.62	0.76	0.91

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[M_0 – No mulch, M_1 - Black polythene, M_2 - Water hyacinth, M_3 - Rice straw].

Table 10. Combined effect of S and B fertilizer with different mulch materials on bulb (%), weight (g) of fresh leaf, Dry matter content of leaf (%) and weight (g) of individual bulb

Treatments	Percent of dry matter content of bulb (%)	Fresh weight of leaves per plant (g)	Dry matter content of leaf (%)	Individual bulb weight (g)
F_oM_o	10.52 l	15.16 m	13.42 k	28.40 j
F_oM_1	12.11 i	20.21 i	17.28 i	34.80 g
F_oM_2	11.41 j	17.01 k	15.02 j	30.73 i
F_oM_3	10.98 k	16.20 l	14.36 j	30.27 i
F_1M_o	11.55 j	18.36 j	17.01 i	32.53 h
F_1M_1	15.34 e	24.60 f	23.13 e	37.47 de
F_1M_2	13.73 g	23.07 g	21.34 f	36.53 ef
F_1M_3	13.43 g	21.45 h	20.10 g	35.47 f
F_2M_o	12.55 h	20.47 i	19.00 h	35.33 fg
F_2M_1	16.89 b	28.34 bc	25.52 bc	41.53 bc
F_2M_2	15.84 d	26.38 d	24.25 d	37.87 d
F_2M_3	14.23 f	25.18 e	21.88 f	37.07 de
F_3M_o	12.80 h	21.45 h	20.10 g	35.47 f
F_3M_1	17.62 a	29.30 a	27.48 a	42.40 a
F_3M_2	17.13 b	28.58 b	26.13 b	41.88 b
F_3M_3	16.36 c	27.94 c	25.26 c	39.87 c
CV %	9.54	10.27	7.56	13.37
LSD (0.05)	0.30	0.47	0.70	0.46

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[F_0 - Control, F_1 - ($S_{20kg/ha}$ and $B_{1kg/ha}$), F_2 - ($S_{40kg/ha}$ and $B_{2kg/ha}$), F_3 - ($S_{60kg/ha}$ and $B_{3kg/ha}$), M_0 - No mulch and no irrigation, M_1 - Black polythene, M_2 - Water hyacinth, M_3 - Rice straw]

4.11. Yield per plot (Kg)

Yield per plot was found to be significantly influenced by different doses of sulphur and boron treatment application (Table 11). The highest yield per plot (0.80 kg) was obtained from the F_3 ($S_{60kg/ha}$ + $B_{3kg/ha}$) whereas the lowest yield per (0.62 kg) F_0 (control).

Yield per plot was significantly influenced by the effect of mulching treatments (Table 12). The highest yield per plot (0.78 kg) was obtained from the treatment M_1 (Black polythene) followed by the yield (0.74 kg) of treatment M_2 (water hyacinth).

These results were agreed with the findings of Mia (2006) and Akter (2017) they reported that mulching gave higher bulb yield compare to unmulched condition.

Yield per plot was significantly influenced by the combination of S and B fertilizer with different mulch materials (Table 13). The highest yield per plot (0.85 kg) was obtained from the F_3M_1 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) treatment which was followed by F_3M_2 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with water hyacinth mulch) treatment whereas the lowest yield per plot (0.57 kg) was obtained from the F_oM_o treatment.

4.12. Yield per hectare (t)

Yield per hectare was significantly varied due to the effect of different doses of sulphur and boron treatment (Table 11). The highest yield (9.98 t/ha) was obtained from the treatment F_3 ($S_{60kg/ha}$ + $B_{3kg/ha}$) whereas the lowest yield (7.76 t/ha) was obtained from the treatment F_0 (control) (Table 14). These results were agreed with the findings of Paul*et al.* (2007). They said that proper or balance doses of fertilization helped better growth and yield of onion..

Yield per hectare was significantly influenced by the effect of mulching treatments (Table 12). The highest yield (9.76 t/ha) was found from the M_1 (black polythene) treatment followed by the yield (9.20 t/ha) from M_2 (water hyacinth) and M_3 (rice straw). The lowest yield (8.23 t/ha) was found from the M_0 (no mulch) treatment. These results were agreed with the previous findings. Polythene mulch increases soil temperature and moisture. These synthetic mulches reduce weed problems and certain insect pests and also stimulate higher crop yields by more efficient utilization of soil nutrients (Kashi*et al.*, 2004).

Yield per hectare was significantly influenced by the combined effect of S and B fertilizer with different mulch materials (Table 13). The highest yield (11.21 t/ha) was found from the F_3M_1 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) treatment and

followed by F_3M_2 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with water hyacinth mulch) whereas the lowest yield (6.56 t/ha) was found from the F_oM_o treatment.

Table 11. Effect of sulphur and boron fertilizer on the yield of onion per plot and yield per hectare

Treatments	Yield per plot (kg)	Yield per ha (t)
F_o	0.62 d	7.76 d
F_1	0.71 c	8.88 c
F_2	0.76 b	9.49 b
F_3	0.80 a	9.98 a
CV %	11.42	12.43
LSD (0.05)	31.40	0.32

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[F_0 - Control, F_1 - ($S_{20kg/ha}$ and $B_{1kg/ha}$), F_2 - ($S_{40kg/ha}$ and $B_{2kg/ha}$), F_3 - ($S_{60kg/ha}$ and $B_{3kg/ha}$)].

Table 12. Effect of mulches on yield per plot and yield per hectare

Treatments	Yield per plot (kg)	Yield per ha (t)
M_o	0.66 d	8.23 d
M_1	0.78 a	9.76 a
M_2	074 b	9.20 b
M_3	0.71 c	8.92 c
CV %	11.42	12.43
LSD (0.05)	18.14	0.21

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[M_0 – No mulch, M_1 - Black polythene, M_2 - Water hyacinth, M_3 - Rice straw].

Table 13. Combined effect of S and B fertilizer with different mulch materials on yield per plot and yield per hectare

Treatments	Yield per plot (kg)	Yield per ha (t)
F_oM_o	0.57 j	6.56 h
F_oM_1	0.70 g	8.70 fg
F_oM_2	0.61 i	7.68 gh
F_oM_3	0.61 i	7.37 gh
F_1M_o	0.65 h	8.13 g
F_1M_1	0.75 de	9.37 cde
F_1M_2	0.73 ef	9.13 de
F_1M_3	0.71 f	8.87 e
F_2M_o	0.71 fg	8.83 ef
F_2M_1	0.83 b	10.38 bc
F_2M_2	0.76 d	9.47 cd
F_2M_3	0.74 e	9.27 de
F_3M_o	0.71 f	8.87 e
F_3M_1	0.85 a	11.21 a
F_3M_2	0.84 ab	10.50 b
F_3M_3	0.80 c	9.97 c
CV %	11.42	12.43
LSD (0.05)	7.83	0.42

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

[F_0 - Control, F_1 - ($S_{20kg/ha}$ and $B_{1kg/ha}$), F_2 - ($S_{40kg/ha}$ and $B_{2kg/ha}$), F_3 - ($S_{60kg/ha}$ and $B_{3kg/ha}$), M_0 - No mulch and no irrigation, M_1 - Black polythene, M_2 - Water hyacinth, M_3 - Rice straw]

4.13. Economic analysis

Input costs for land preparation, manure, mulching, irrigation and manpower required for all the operations from seed sowing to harvesting of onion were recorded as per experimental plot and converted into cost per hectare. Price of onion was considered as per market rate. The economic analysis presented under the following headings-

4.13.1. Gross income

The combination of different manure and mulching showed different value in terms of gross return under the trial (Table 14) (Appendix XII). The highest gross return (Tk. 3,36,300) was obtained from the treatment combination F_3M_1 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch). The lowest gross return (Tk. 1,31,200) was obtained from treatment F_oM_o.

4.13.2. Net return

In case of net return, different treatment combination showed different concentration of net return. The highest net return (Tk. 1,88,934) was found from F_3M_1 treatment and the second highest net return (Tk. 1,38,228) was obtained from F_1M_1 treatment. The lowest (Tk. 25,966) net return was obtained F_oM_o treatment (Table 14).

4.13.3. Benefit cost ratio

The highest benefit cost ratio (2.28) was noted from the treatment combination of F_3M_1 and the lowest benefit cost ratio (1.25) was obtained from F_oM_o treatment (Table 14). From economic point of view, it is apparent from the above results that F_3M_1 treatment ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) was more profitable treatment combination than rest of the combinations.

Table 14. Cost and return of onion cultivation as influenced by fertilizer and mulching

Treatments	Total cost of production (Tk)	Yield (ton/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio
F_oM_o	105,235	6.56	1,31,200	25,966	1.25
F_oM_1	130,513	8.70	2,61,000	130,487	2.00
F_oM_2	114,784	7.68	1,92,000	77,216	1.67
F_oM_3	119,278	7.37	1,84,250	64,972	1.54
F_1M_o	117,593	8.13	1,62,600	45,007	1.38
F_1M_1	142,872	9.37	2,81,100	138,228	1.97
F_1M_2	127,143	9.13	2,28,250	101,107	1.80
F_1M_3	131,637	8.87	2,21,750	90,113	1.68
F_2M_o	119,840	8.83	1,76,600	56,760	1.47
F_2M_1	145,119	10.38	3,11,400	166,281	2.15
F_2M_2	129,390	9.47	2,36,750	107,360	1.83
F_2M_3	133,884	9.27	2,31,750	97,866	1.73
F_3M_o	122,087	8.87	1,77,400	55,313	1.45
F_3M_1	147,366	11.21	3,36,300	188,934	2.28
F_3M_2	131,637	10.50	2,62,500	130,863	1.99
F_3M_3	136,131	9.97	2,49,250	113,119	1.83

[F_0 - Control, F_1 - ($S_{20kg/ha}$ and $B_{1kg/ha}$), F_2 - ($S_{40kg/ha}$ and $B_{2kg/ha}$), F_3 - ($S_{60kg/ha}$ and $B_{3kg/ha}$), M_0 - No mulch and no irrigation, M_1 - Black polythene, M_2 - Water hyacinth, M_3 - Rice straw]

Total cost of production was done in details according to the procedure of Krishitattik Fasaler Utpadan O Unnayan (in Bangla), by Alam *et al.* (1989).

Sale of manure treated onion @ Tk. 30,000/ton

Sale of non-treated onion @ Tk. 20,000/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 CONCLUSION

A field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from October, 2018 to March, 2019 to find out the growth and yield of onion as influenced by sulphur and boron with mulch materials. The experiment consisted of two factors: Factor A: Four doses of boron and sulphur fertilizer viz. F_0 = $S_{0kg}B_{0kg/ha}$ (Control), F_1 = $S_{20k}gB_{1kg/ha}$ (Sulphur 20 kg/ha and Boron 1 kg/ha), F_2 = $S_{40kg}B_{2kg/ha}$ (Sulphur 40 kg/ha and Boron 2 kg/ha), F_3 = $S_{60kg}B_{3kg/ha}$ (Sulphur 60 kg/ha and Boron 3 kg/ha) and Factor B: Four types of mulch viz. M_0 = No mulch and no irrigation, M_1 = Black polythene, M_2 = Water hyacinth and M_3 = Rice straw.. There were 16 treatment combinations and experiment was setup in Randomized Complete Block Design (RCBD) with three replications.

Collected data were statistically analyzed for the evaluation of treatments for the detection of the best treatment of manure, mulch and the best amalgamation. Summary of the results and conclusion have been described in this chapter.

Summary

In case of sulphur and boron treatment, the highest plant height (53.38 cm) and lowest plant height (47.88 cm) was obtained at 60 DAT from F_3 and F_0 treatments, respectively. On the other hand, observing the mulch treated plants, highest plant height (52.51 cm) and lowest plant height (48.85 cm) was observed at 60 DAT from M_1 and M_0 treatments respectively. In case of combined effect highest plant height (55.54 cm) and the lowest plant height (47.13 cm) was obtained from F_3M_1 and F_oM_o treatment, respectively.

Maximum leaf number (10.48) and minimum leaf number (7.45) per plant was obtained at 60 DAT from F_3 and F_0 treatments, respectively. On the other hand,

observing the mulch treated plants, maximum leaf number (10.19) and minimum leaf number (7.93) per plant was obtained at 60 DAT from M_1 and M_0, respectively. In case of combined effect, maximum leaf number (11.47) and the minimum leaf number (6.90) was obtained from F_3M_1 and F_oM_o treatment, respectively.

In case of sulphur and boron fertilizer treatment the highest bulb length (4.83 cm) and lowest bulb length (2.62 cm) was obtained from F_3 and F_0 treatments, respectively. On the other hand, observing the mulch treated plants, highest bulb length (4.52 cm) and lowest bulb length (2.99 cm) was observed from M_1 and M_0 treatments, respectively. In case of combined effect, longest bulb length (5.51 cm) and the shortest bulb length (2.25 cm) was obtained from F_3M_1 and F_oM_o treatment, respectively.

In sulphur and boron treated plants, the maximum bulb diameter (6.00 cm) was found from the F_3 treatment and the minimum bulb diameter were recorded from the F_0 (3.98 cm) treatments. Whereas in mulch treated plants, the highest bulb diameter (5.74 cm) was recorded with M_1 treatment and lowest bulb diameter (4.33 cm) was obtained from M_0 (control) treatment. In case of combined effect, the highest bulb diameter (6.68 cm) was recorded with treatment F_3M_1 whereas the lowest bulb diameter (3.67 cm) was obtain from F_oM_o treatment.

In case of fertilizer treatment, during harvesting maximum neck diameter (1.31 cm) was obtained from F_3 treatment and minimum neck diameter (1.09 cm) was recorded from control F_0 treatment. The maximum neck diameter (1.26 cm) was obtained from M_1 treatment and the minimum neck diameter was recorded from M_0 (1.13 cm) treatment from mulch application. In amalgamation, during harvesting maximum diameter of neck (1.42 cm) showed from the F_3M_1 treatment and minimum from the F_oM_o (1.03 cm) treatment.

Regarding fertilizer treatment, the longest root length was found from the treatment F_3 (7.78 cm) and the shortest was found from F_0 (6.29 cm) treatment. In mulch application, the longest root length were found from the treatment M_1 (7.39 cm) and the shortest from the M_0 (6.95 cm) treatment. In combined effects, the longest root length (7.90 cm) was found from the treatment F_3M_o. And the shortest root length were found from the treatment F_oM_1 (5.97 cm).

In case of fertilizer, the highest dry matter content was found from F_3 (15.98%) treatment and the lowest from F_0 (11.26%) treatment. Regarding mulch, the highest dry matter content was found from the M_1 (15.49%) treatment and lowest from the M_0 (11.86%) treatment. In amalgamation, the highest dry matter content was found from the F_3M_1 (17.62%) treatment and lowest showed from the treatment F_oM_o (10.52 %).

In case of fertilizer, the highest fresh leaf weight (26.82 g), dry matter content of leaf (24.74 %), single bulb weight (39.93 g), yield per plot (0.80 kg) and yield per hectare (9.98 t) were obtained from F_3 treatment. And lowest fresh leaf weight (17.15 g), dry matter content of leaf (15.02 %), single bulb weight (31.05 g), yield per plot (0.62 kg) and yield per hectare (7.76 t) were obtained from F_0 treatment. Regarding mulching, the highest fresh leaf weight (25.61 g), dry matter content of leaf (23.35 %), single bulb weight (39.05 g), yield per plot (0.78 kg) and yield per hectare (9.76 t) were obtained from M_1 treatment. And lowest fresh leaf weight (18.86 g), dry matter content of leaf (17.38 %), single bulb weight (32.93 g), yield per plot (0.66 kg) and yield per hectare (8.23 t) were obtained from M_0 treatment. In case of combined effect, the highest fresh leaf weight (29.30 g), dry matter content of leaf (27.48 %), single bulb weight (42.40 g), yield per plot (0.85 kg) and yield per hectare (11.21 t) were obtained from F_3M_1 treatment. And lowest fresh leaf weight (15.16 g), dry

matter content of leaf (13.42 %), single bulb weight (28.40 g), yield per plot (0.57 kg) and yield per hectare (6.56 t) were obtained from F_oM_o treatment.

The highest gross return (Tk. 3,36,300/ha), net return (Tk. 1,88,934/ha) and benefit cost ration (2.28) was obtained from the treatment combination F_3M_1 ($S_{60kg/ha}$ + $B_{3kg/ha}$ with black polythene mulch) and the lowest gross return (Tk. 1,31,200/ha), net return (25,966/ha) and benefit cost ratio (1.25) was obtained from F_oM_o treatment.

Conclusion

Based on the findings of the experiment, it may be concluded that for efficient production of onion and maintenance of soil productivity, it is judicial to use sufficient amount of sulphur and boron combination with black mulch as an alternative shortage of irrigation. The result revealed that combined application of 60 kg sulphur and 3 kg of boron per hectare was found best for higher yield of onion. The recent study also revealed that the successful onion production is possible by using mulches. Use of black polythene mulch may be suggested for this purpose.

Recommendation

- A combination of S and B @ 60 kg – 3 kg per hectare was found to be the best for the production of higher bulb yield of onion.
- Higher bulb production is possible by using mulches as an alternative to irrigation. Black polythene mulch is found to be best for this purpose.

Therefore, the treatment combination of 60 kg sulphur and 3 kg of boron per hectare with black polythene mulch may be used where precipitation is scanty and irrigation is costly. Since the present study was conducted in only one agro-ecological zone, further investigations are needed to be carried out in other AEZ of Bangladesh.

CHAPTER VI

REFERENCES

Akter, M. (2017). Effect of manures and mulches on the growth and yield of onion.M.S. thesis. Dept. of Horticulture. SAU. Dhaka. pp. 37-43.

Alam, M. S., Iqbal, T. M. T., Amin, M. S. and Gaffer, M. A. (1989). Krishitattik Fasaler Utpadan O Unnayan (in Bengali). T. M. Jabair Bin Iqbal, Serajgonj. pp. 231-239.

Anisuzzaman, M., Asrafuzzaman, M., Ismail, M. and Rahim, M. A. (2009). Planting time and mulching effect on onion development and seed production. *African J. Biot.* **8**(3): 412–416.

Anonymous (1998). Monthly Statistical Bulletin of Bangladesh.Bangladesh Bureau of Statistics. Ministry, Govt. of the People‟s Republic of Bangladesh, Dhaka.P.54.

Anonymous. (2000). Production technology of onion BARI Piaz-1, 2 and 3 (in Bengali) leaflet. Spices Research Centre. BARI. Bogra. pp. 1-4.

Azam, M. G. (2005). Effect of different mulches on growth and yield of onion.M.S. thesis. Dept. of Crop Botany. BAU. Mymensingh. pp. 22-29.

Azed, A. K., Soren, E. B. and Touria, E. (2015). Effects of mulching and micronutrient management on growth and yield of onion. *Hortic. Technol.* **10**(2): 26-33.

BBS (2016).Year Book of Agricultural Statistics -2014. 26th Series. Bangladesh Bureau of Statistics, Statistics and Informatics Division. Ministry of Planning. Govt. of the People‟s Republic of Bangladesh, Dhaka.p.8.

Bell, A. A. (1981). Biochemical mechanisms of disease resistance. *Annu. Rev. Plant Physiol*. **32**: 21-81.

Chattopadhyay, A. and Mukhopadhyay, R. (2004). Response of onion to boron and molybdenum as foliar feeding. *Indian J. Orn. Hort.* **13**(1): 11.

Chowdhury, S. H., Ali, M. S., Hossain, M. A., Ahmed, M. U. and Hoque. M. M. (2004). Effect of boron and sulphur on yield and quality of onion seed. *Bangladesh J. Agric. Sci.***22**: 179-184.

El-Oksh II, El-Gizawy A. M., Abdallah, M. M. F., Mohamed, A. G. and Abdallah, A. G. (1993). Effect of soil moisture and nitrogen fertilizer levels on onion grown in mixture in tafla and seed.*Cairo. Agric. Univ.* **44**(1): 145-156.

Encyclopedia (2017), http://www.encyclopedia.com/ plantsand-animals/plants/onions.

FAO (2013), Crop Water Information: Onion. www.fao.org/water/cropinfo_onions.

FAO (2016), Production Year Book, Food and Agriculture Organization (FAO), Rome, Italy. www.fao.org/statistics/en

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

Gomez, A. K. and Gomez, A. A. (1984). Staristical Procedures for Agricultural Research.Second Edition. John Wiley and Sons! New York, U.S.A.

Hamma, I. L. (2013). Growth and yield of onion as influenced by planting dates and mulching types in Samaru, Zaria. *Int. J. Adv. Agric. Res.* **3**(2): 22-26.

Haque, S., Islam, R., Karim, A. and Khan, A. H. (2003).Effects of natural and synthetic mulches on garlic (*Allium sativum* L.). *Asian J. Plant Sci.* **2(**1): 83-89.

Howlader, M. M., Kamruzzaman, M. M., Chowdhury, M. E. K. and Yousuf. M. N. (2010). Effect of phosphorus, potassium and boron on onion seed production.Research Report. Spices Research Centre. *Bangladesh Agric. Res. Inst*. pp.13-17.

Inusah, B. I. Y., Wiredu, A. N., Yirzagla, J., Mawunya, M. and Haruna, M. (2013). Effects of different mulches on the yield and productivity of drip irrigated onions under tropical conditions. *Int. J. Adv. Agric. Res.***1**: 133-140.

Inusah, I. Y. B., Alexander, N. W., Yirzagla, J., Mawunya, M. and Haruna, M. (2013). Effects of different mulches on the yield and productivity of drip irrigated onions under tropical conditions. *Int. J. Adv. Agric. Res.* **6**(2): 133-140.

Islam, K.S., Miah, M.H.A. and Ahmed, S.U. (2010). Effect of Mulch and Different Levels of N and K on the Growth and Yield of Onion. *Progress. Agric*. **21**(1 & 2): 39 – 46.

Islam, M.N., Ahmed, S.U., Hossain, M.M. and Chowdhury, S. (2002). Effect of mulch and bulb size on growth of onion. *Pakistan J. Biol. Sci.* **5**: 648-650.

Jaggi, R. and Dixit, S. (1999). Onion (*Allium cepa*) responses to sulphur in representative vegetable growing soils of Kangra Valley of Himachal Pradesh. *Indian J. Agric. Sci.* **69**: 289-291.

Jaggi, R. C. (2004). Effect of sulphur levels and sources on composition and yield of onion (*Allium cepa*). *Indian J. Agril. Sci.* **74**(4): 219-220.

Jaggi, R. C. (2005). Sulphur levels and sources affecting yield and yield attributes in onion (*Allium cepa*). *Indian J. Agril. Sci.* **75**(3): 154-156.

Jamil, M., Munir, M., Qasim, M., Jalal, B. and Rehman, K. (2005). Effect of different types of mulches and their duration on the growth and yield of garlic. *Intl. J. Agric. Biol.* **7**(4): 588-591.

Jamil, M., Munir, M., Quasim, M. J. and Rehman, K. (2005). Effect of different types of mulches and their duration on the growth and yield of garlic. *Int. Jur. agi. and bio.* pp: 799-812.

Kashi, A., Hosseinzadeh, S., Babalar, M. and Lessani, H. (2004). Effect of black polyethylene mulch and calcium nitrate application on growth, yield of watermelon (*Citrullus Lanatus*). *J. Sci. Tech. Agric. Nat. Res.* **7**: 1-10.

Kumar, A. and Singh, O. (1995). Effect of sulphur deficiency on plant growth and yield of onion. *Indian J. Agric. Res.* **28**: 127-130.

Kumar, A. and Singh, O. (1999). Sulphur deficiency symptoms in onion plants. *Agril.Sci. Digest Karnal*.**19**(1): 1-3.

Mahajan, G., Sharda, R., Kumar, A. and Singh K. G. (2007). Effect of plastic mulch on economizing irrigation water and weed control in baby corn sown by different methods. *Afri. J.Agri. Res.* **2**(1): 19-26.

Meena, O. S. and Singh, D. (1998). Effect of sulphur and zinc application on onion yield and sulphur and zinc uptake in three soil orders. *J. Indian Soci. Soil Sci.* **46**(4): 636-640.

Mia, M. H. (2006). Effect of mulch and different levels of N and K on the growth, bulb yield and seed yield of onion.M.S. thesis, Dept. Hort. BAU, Mymenshing. pp.75-76.

MoA (2016), Statistical Yearbook of Agricultural of Bangladesh. Statistics Division, Ministry of Agriculture, Govt. of the Peoples Republic of Bangladesh, Dhaka, p 119. DOI: org/ 10.1016/j.rse.2005.10.004.

Mukhopadhyay, A. and Chattopadhyay, S. K. (1999). Effects of boron and molybdenum on growth and yield of onion. *Plant Sci. Lett.* **14**:193-198.

Nagaich, K. N., Trivedi, S. K. and Lekhi, R. (1999). Effect of sulphur and potassium fertilization in onion (*Allium cepa* L.). *Hort. J.* **12**(1): 25-31.

Nasreen, S. and Huq, S. M. I. (2005). Effect of sulphur fertilization on yield, sulphur content and uptake by onion. *Indian J. Agril. Res.* **39**(2): 122-127.

Nasreen, S., Haq, S. M. I. and Hossain, M. A. (2003). Sulphur effects on growth responses and yield of onion. *Asian J. Plant Sci.* **2**(12): 897-902.

Nasreen, S., Yousuf, M. N., Mamun, A. N. M., Brahma, S. and Haque, M. M. (2009). Response of garlic to zinc, boron and manure application. *Bangladesh J. Agril. Res.* **34**(2): 239-245.

Paul, J. K., Halder, B. C. and Khan, M. A. (2007). Effect of boron and sulphur on the growth and yield of onion. *J. Sci. technol*. **5**: 60-66.

Qureshi, A. A. and Lawande, K. E. (2006). Response of onion (*Allium cepa*) to sulphur application for yield, quality and its storability in S-deficient soils. *Indian J. Agril. Sci.* **76**(9): 535-537.

Rahman, M. A., Mahmud, J. A. and Islam, M. M. (2013). Influence of mulching on the growth and yield of onion. *Tech. J. Engin. Appl. Sci*. **3**(24): 3497-3501.

Rashid, A. M.. Khan, A. M. and Ullah. M. A. (2007). Effect of sulphur and boron on onion seed production.Research Report. Spices Research Centre. Bangladesh Agric. Res. Inst., 05-09.

Rhee, K. M., Yoon, J. H. and Park, J. K. (1990). Effect of polythene film mulching on the changes of soil chemical properties during the sesame cropping season. *Res. Rep. Rur. Adm., soil Fert. Abstr*. **54**: 116-27.

Saieed, M. A. U., Fakir, M. S. A. and Sarkar. A. R. (2010). Effect of boron and Molybdenum on yield and quality of onion seed. *Bangladesh J. Agric. Sci. Tech*. **5**(3&4): 53-56.

Shakirullah, Ishtiaq, M., Ali, R., Shah, S. I. and Sarhad, H. (2002). Effect of different levels of sulphur on yield and pungency of onion. *Pakistan J. Agric.* **18**(2): 183-187.

Sharma, M. P., Singh, A. and Gupta, J. P. (2002). Sulphur status and response of onion *Allium cepa* to applied sulphur in soils of Jammu districts. *Indian J. Agril. Sci.* **72**(1): 26-28.

Singh, D. and Pandy, R. N. (2005).Effect of applied sulpher on dry matter yield and sulpher uptake by onion in different soil series of Delhi. *Ann. Agril. Res.* **16**(3): 348-350.

Singh, S. K., Kumar, S. and Chand, S. (2017). Effect of mulching on the growth and yield of onion (*Allium cepa* L.). *HortFlora Res. Spectrum*. **6**(2): 134-136.

Smriti, S., Kumar, R. and Singh, S. K. (2002). Effect of sulphur and boron nutrition on growth, yield and quality of onion (*Allium cepa* L.). *J. Applied Biol.* **12**(1/2): 40-46.

Stowell, B. (2000). Organic kiwifruit production–maintaining soil fertility and yields. Kiwifruit, **139**: 18–21.

Suh, J. K., Kim, Y. B., Lee, Y. S. and Han, K. Y. (1991). A study of the improvement of mulching cultivation method for onion (*Allium cepa* L.). *Res. Rep. Rural. Dev. Adm. Hort.* **33**(2):31-36.

Suresh, C. H. (2007). Studies on effect of organics on seed yield and quality in onion. MS thesis. Dept. of seed science and technology. Dharwad University of Agricultural Science. Dharwad.

Tao, G., Junling, Z., Christic, P. and XiaoLin, L. (2006). Influence of nitrogen and sulphur fertilizers and inoculation with arbuscular mycorrhizal fungi on yield and pungency of spring onion. *J. Plant Nuti.* **29**(10): 1767-1778.

Vander, Z., Demagante, A., Acasia R, Domingo, A. and Hagerman, H. (1986). Response of solanum potatoes to mulching during different seasons in an isohyperthemic environment in the Philippines. *Trop. Agric.* **63**: 229-239.

Vavrina, C. S. and Roka, F. M. (2000). Comparison of plastic mulch and bare ground production and economics for short-day onion in a semi tropical environment. *Hortic. Technol*. **10**:326-333.

Verma, D. P., Sharma, B. R., Chadha, A. P. S., Bajpai, H. K. and Bhadauria, U. P. S. (2005). Effect of boron in soil on physiological and biochemical characteristics, yield and quality of onion.*Adv. Plant Sci.* **9**(2): 39-41.

Vitosh, M. L. Warncke, D. D. and Lucas, R. E. (2001). Secondary and micronutrients for vegetables and field crops. *Crop Soil Sci.* **5**: 18-36.

Woldetsadik, K., Gertsson, U. and Ascard J. (2003). Response of shallots to mulching and nitrogen fertilization. *Hort. Sci.* **38**(2): 217-221.

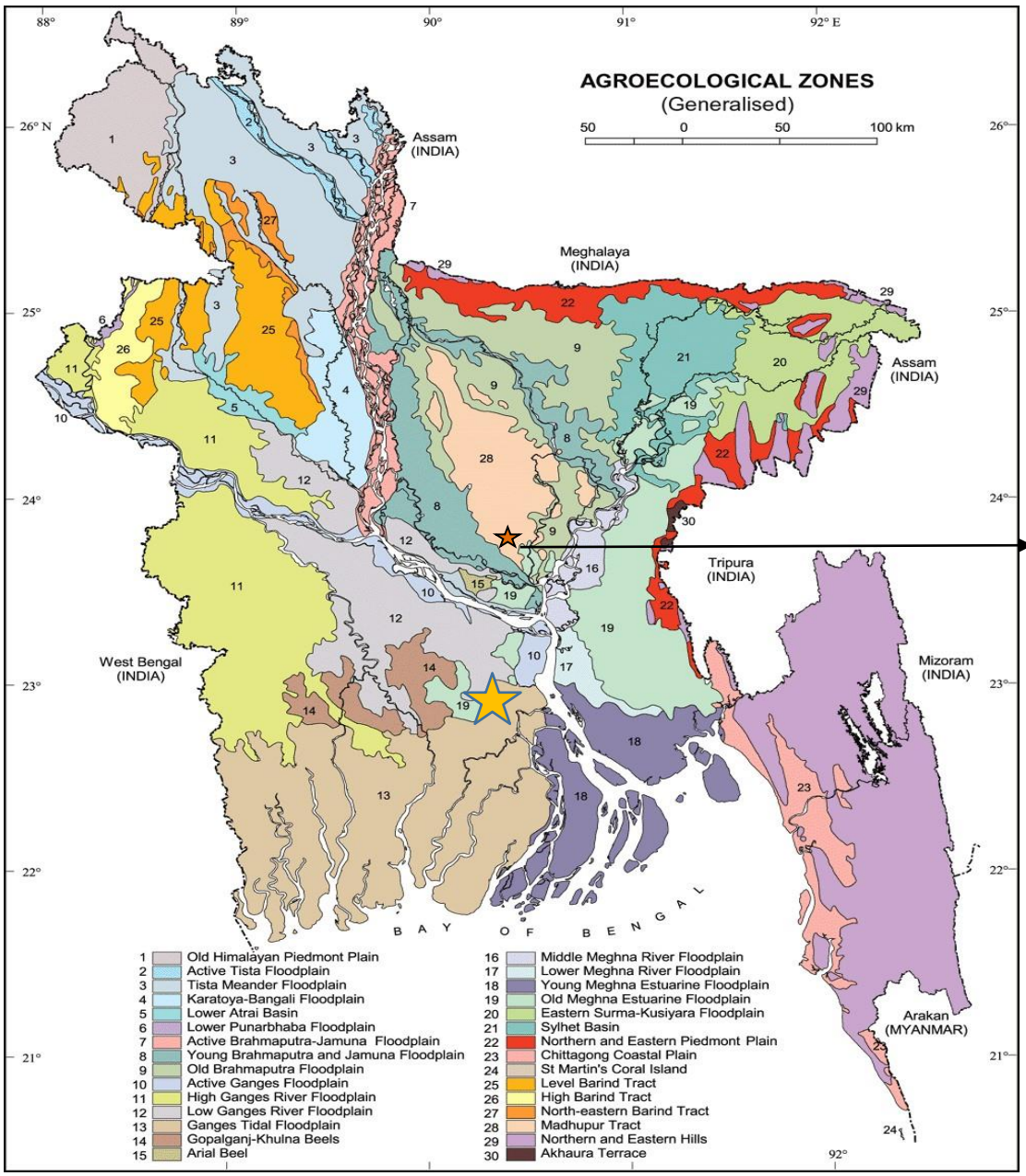
Yadav, P., Abidi, A. B. and Yadav, V. K. (2004). Effect of gibberellic acid and sulphur on quality of onion bulbs. *Plant Archives*. **4**(1): 175-177.

Zayton A. M. (2007). Effect of soil-water stress on onion yield and quality in sandy soil. *Misr J. Ag. Eng*. **24**: 141-160.

CHAPTER VI

APPENDICES

Appendix I: Map showing the experimental site



Appendix II: Morphological Characteristics of the Experimental Field

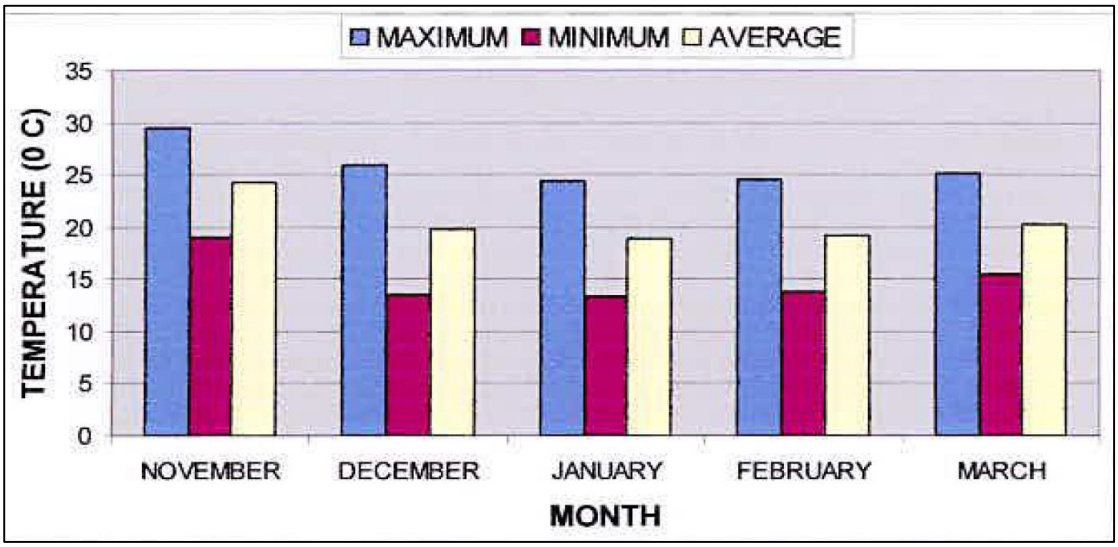
Morphology	Characteristics
Location	SAU farm, Dhaka
Agro-ecological zone	Madhupur Tract (AEZ-28)
General Soil Type	Deep Red Brown Terrace Soil
Parent material	Madhupur Clay
Topography	Fairly level
Drainage	Well drained
Flood level	Above flood level

(FAO and UNDP, 1988)

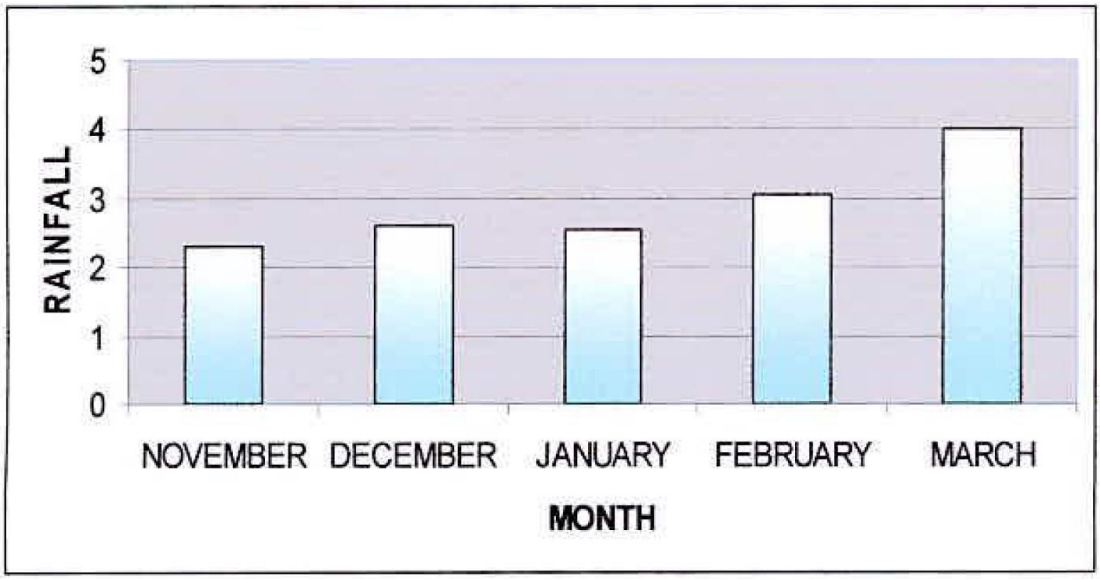
Appendix III: Initial Physical and Chemical Characteristics of the Soil

Characteristics		Value
Mechanical fraction:	% Sand (2.0-0.02 mm)	22.26
	% Silt (0.02-0.002 mm)	56.72
	% Clay (<0.002 mm)	20.75
Textural Class		Silt Loam
pH (1:2.5 Soil-water)		5.9
Organic Matter (%)		1.09
Total N (%)		0.06
Available K (ppm)		15.63
Available P (ppm)		10.99
Available S (ppm)		6.07

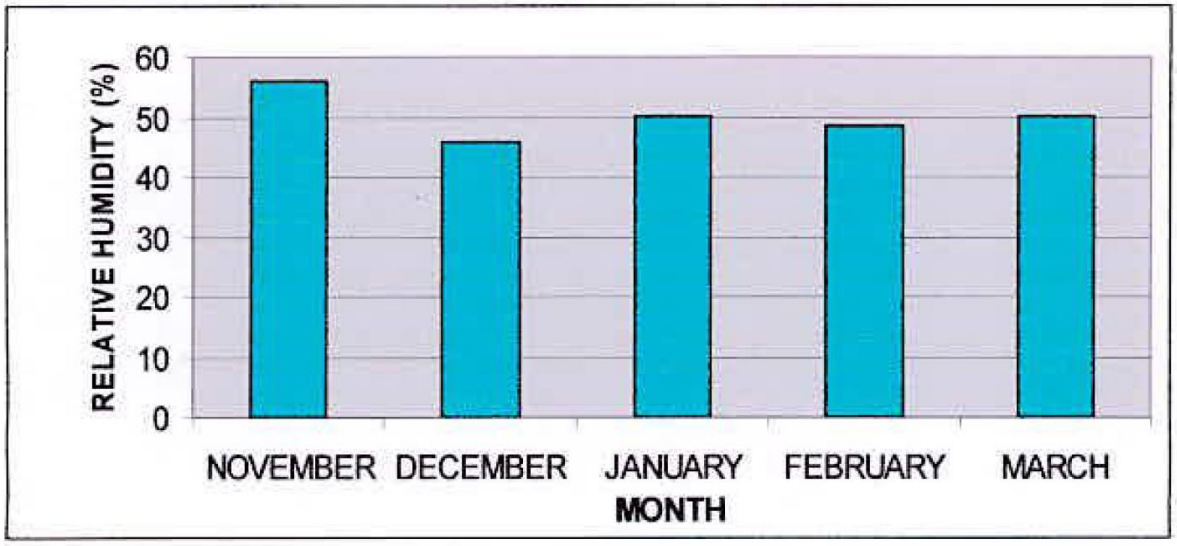
Appendix IV: Monthly average, maximum and minimum air temperature (^{0}C) of the experimental site, Dhaka during the growing time (November, 2018 to March 2019)



Appendix V: Monthly total rainfall (mm) of the experimental site, Dhaka during the growing period (November, 2018 to March 2019)



Appendix VI: Monthly average relative humidity (%) of the experimental site, Dhaka during the growing period (November, 2018 to March, 2019)



Appendix-VII. Analysis of variance of data on plant height at different days after transplanting of onion

Source of variation	Degrees of freedom (df)	Mean Square of Plant height			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	2.290	2.108	0.021	9.991
Factor A (B & S)	3	2.637 ^{NS}	64.250**	6.195**	97.014**
Factor B (Mulch)	3	3.808 ^{NS}	75.811**	9.876**	12.570 **
A x B	9	1.771 ^{NS}	35.811*	3.697*	44.302*
Error	30	5.142	23.237	1.005	15.549

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix-VIII. Analysis of variance of data on number of leaves per plant at different days after transplanting of onion

Source of variation	Degrees of freedom (df)	Mean Square of number of leaves per plant			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	20.701	0.041	5.472	249.51
Factor A (B & S)	3	9.121 ^{NS}	1.262*	101.372**	1406.03**
Factor B (Mulch)	3	4.005 ^{NS}	4.093**	125.430**	5201.43**
A x B	9	8.951^{NS}	1.406*	61.426*	411.14*
Error	30	23.059	0.643	21.988	132.67

* Significant at 0.05 level of probability; **Significant at 0.01 level of probability and ^{NS} Non-significant

Appendix-IX. Analysis of variance of data on length of bulb, diameter of bulb, diameter of neck and root length of onion

Source of variation	Degrees of freedom (df)	Mean Square of number of			
		Length of bulb (cm)	Diameter of bulb (cm)	Diameter of neck (cm)	Root length (cm)
Replication	2	443.5	10.184	1.208	34.176
Factor A (B & S)	3	2409.3**	101.504**	2.686 NS	124.404**
Factor B (Mulch)	3	45510.2**	142.251**	2.063 NS	111.871**
A x B	9	6428.8**	54.488**	1.935 NS	80.167*
Error	30	535.4	4.196	1.917	26.971

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix-X. Analysis of variance of data on percent dry matter content of bulb (%), weight (gm) of fresh leaf, weight (gm) of dry leaf and weight (gm) of single bulb

Source of variation	Degrees of freedom (df)	Mean Square of number of			
		Percent of dry matter content (%)	Weight of single fresh leaf (gm)	Dry matter content of leaf (%)	weight of single bulb(gm)
Replication	2	6.458	1.003	2.554	23.042
Factor A (B & S)	3	44.714*	8.215**	98.936**	126.647**
Factor B (Mulch)	3	35.989*	5.517**	89.951**	113.002**
A x B	9	24.353*	3.415*	48.768*	59.758*
Error	30	1.452	1.136	15.443	19.452

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix XI. Analysis of variance of data on yield of onion per plot and yield per hectare of onion

Source of variation	Degrees of freedom (df)	Mean Square of number of	
		Yield per plot (g)	Yield per ha (t)
Replication	2	41.382	8.108
Factor A (B & S)	3	123.332*	89.543**
Factor B (Mulch)	3	111.010*	71.631**
A x B	9	129.268*	67.807*
Error	30	3.018	12.064

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability and NS Non-significant

Appendix XII. Per hectare production cost of onion as influenced by Boron and Sulphur with mulch materials

A. Input cost

Treatments combination	Labour cost	Ploughing cost	Seed cost	Insecticide cost	Irrigation cost	Inorganic Fertilizer + Mulch cost	Sub Total (A)
F_oM_o	35,000	18,000	6,000	5,500	2,500	0	67,000
F_oM_1	38,000	18,000	6,000	4,500	1,000	22,000	89,500
F_oM_2	36,000	18,000	6,000	5,000	1,500	9,000	75,500
F_oM_3	36,000	18,000	6,000	5,000	1,500	13,000	79,500
F_1M_o	35,000	18,000	6,000	5,500	2,500	11,000	78,000
F_1M_1	38,000	18,000	6,000	4,500	1,000	33,000	100,500
F_1M_2	36,000	18,000	6,000	5,000	1,500	20,000	86,500
F_1M_3	36,000	18,000	6,000	5,000	1,500	24,000	90,500
F_2M_o	35,000	18,000	6,000	5,500	2,500	13,000	80,000
F_2M_1	38,000	18,000	6,000	4,500	1,000	35,000	102,500
F_2M_2	36,000	18,000	6,000	5,000	1,500	22,000	88,500
F_2M_3	36,000	18,000	6,000	5,000	1,500	26,000	92,500
F_3M_o	35,000	18,000	6,000	5,500	2,500	15,000	82,000
F_3M_1	38,000	18,000	6,000	4,500	1,000	37,000	104,500
F_3M_2	36,000	18,000	6,000	5,000	1,500	24,000	90,500
F_3M_3	36,000	18,000	6,000	5,000	1,500	28,000	94,500

B. Overhead Cost

Treatment Combination	Cost of lease of land months for 6 months (14% of value of land Tk. 4,00,000/ year)	Miscellaneou s cost (Tk. 5% of the input cost)	Interest on running capital for 6 months (Tk. 14.0% of cost/year)	Sub total (Tk) (B)	Total cost of production (Tk./ha) [Input cost (A)+ overhead cost (B)]
F_oM_o	28,000	3350	6885	38,235	89,506
F_oM_1	28,000	4475	8538	41,013	110,290
F_oM_2	28,000	3775	7509	39,284	94,561
F_oM_3	28,000	3975	7803	39,778	99,055
F_1M_o	28,000	3900	7693	39,593	105,235
F_1M_1	28,000	5025	9347	42,372	130,513
F_1M_2	28,000	4325	8318	40,643	114,784
F_1M_3	28,000	4525	8612	41,137	119,278
F_2M_o	28,000	4000	7840	39,840	117,593
F_2M_1	28,000	5125	9494	42,619	142,872
F_2M_2	28,000	4425	8465	40,890	127,143
F_2M_3	28,000	4625	8759	41,384	131,637
F_3M_o	28,000	4100	7987	40,087	119,840
F_3M_1	28,000	5225	9641	42,866	145,119
F_3M_2	28,000	4525	8612	41,137	129,390
F_3M_3	28,000	4725	8906	41,631	133,884