EFFECT OF MULCH MATERIALS AND NITROGEN ON GROWTH AND YIELD OF SQUASH

ISRAT JAHAN SWEETY

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

JUNE, 2018

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BY

ISRAT JAHAN SWEETY
REG. NO. : 12-05037

A Thesis
Submitted to the Department of Horticulture
Sher-e-Bangla Agricultural University, Dhaka
In partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE (MS)

IN

HORTICULTURE

SEMESTER: JANUARY- JUNE, 2018

Approved by:

Prof. Dr. Md. Ismail Hossain
Department of Horticulture
SAU, Dhaka
Supervisor

Dr. Abul Hasnat M Solaiman
Associate professor
Department of Horticulture
SAU, Dhaka
Co-Supervisor

Prof. Dr. Mohammad Humayun kabir
Chairman
Examination committee

Prof. Dr. Md. Ismail Hossain
Department of Horticulture
Sher -e- Bangla Agricultural University
Dhaka- 1207, Bangladesh
E-mail : ismail_sau@yahoo.com
Mobile No : 01712794223

CERTIFICATE

*This is to certify that the thesis entitled **"EFFECT OF MULCH MATERIALS AND NITROGEN ON GROWTH AND YIELD OF SQUASH"** submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (M.S.)** in **HORTICULTURE**, embodies the result of a piece of bona fide research work carried out by **ISRAT JAHAN SWEETY**, Registration No. **12-05037** 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.

June, 2018
Dhaka, Bangladesh

(Prof. Dr. Md. Ismail Hossain)
Department of Horticulture
SAU, Dhaka
Supervisor

Dedicated to

My

Beloved Parents

ACKNOWLEDGEMENTS

The authoress seems it a much privilege to express her enormous sense of gratitude to the almighty Allah for there ever ending blessings for the successful completion of the research work.

The authoress wishes to express her gratitude and best regards to her respected Supervisor, **Prof. Dr. Md. Ismail Hossain**, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for his continuous direction, constructive criticism, encouragement and valuable suggestions in carrying out the research work and preparation of this thesis.

The authoress wishes to express her earnest respect, sincere appreciation and enomous indebtedness to her respected Co-supervisor, **Dr. Abul Hasnat M Solaiman**, Associate Professor, Department of horticulture, Sher-e-Bangla Aricultural University, Dhaka, for his scholastic supervision, helpful commentary and unvarying inspiration throughout the research work and preparation of the thesis.

The authoress feels to express her heartfelt thanks to the honorable Chairman, **Prof. Dr. Mohammad Humayun Kabir,** Department of Horticulture along with all other teachers and staff members of the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, for their co-operation during the period of the study.

The authoress feels proud to express her deepest and endless gratitude to all of her course mates and friends to cooperate and help her during taking data from the field and preparation of the thesis. The author wishes to extend her special thanks to her lab mates, class mates and friends for their keen help as well as heartiest co-operation and encouragement.

The authoress expresses her heartfelt thanks to her beloved parents, elder sisters and brother and all other family members for their prayers, encouragement, constant inspiration and moral support for her higher study.

The Authoress

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ISRAT JAHAN SWEETY

ABSTRACT

A field experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2017 to February 2018. The experiment was laid out in a Randomized Complete Block Design with three replications. Three mulching treatments *viz*. M_0: No mulch, M_1: Rice straw and M_2: Black polythene and four levels of nitrogen *viz*. N_0: 0 kg N ha^{-1}, N_1: 80 kg N ha^{-1}, N_2: 130 kg N ha^{-1} and N_3: 180 kg N ha^{-1}were considered for the present study. Different mulching treatments and nitrogen doses and also their combinations showed significant influence on different growth, yield contributing parameters and yield of squash. The treatment, M_2 showed highest results in individual fruit weight (456.80 g), and fruit yield ha^{-1} (20.20 t ha^{-1}) compared to control. In case of nitrogen treatments, the highest results in individual fruit weight (512.54 g) and highest fruit yield ha^{-1} (26.79 t ha^{-1}) were found from N_2 compared to control. Likewise, the treatment combination of M_2N_2 gave the highest individual fruit weight (522.00 g) and fruit yield ha^{-1} (28.95 t ha^{-1}) where the lowest results were found from the treatment combination of M_0N_0. The highest gross return (Tk 434250), net return (Tk 305430) and BCR (3.37) were obtained from the treatment combination of M_2N_2 where the lowest was obtained from M_0N_0. So, it can be concluded that black polythene mulch with 130 kg N ha^{-1} is suitable for squash cultivation.

CONTENTS

CONTENTS (Cont'd.)

CONTENTS (Cont'd.)

LIST OF TABLES

LIST OF TABLES (Cont'd)

LIST OF FIGURES

LIST OF APPENDICES

LIST OF PLATES

ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAT	=	Days After Transplanting
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
FAO	=	Food and Agriculture Organization of the United Nations
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^{o}C	=	Degree Celceous
%	=	Percentage
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Squash *(Cucurbita pepo* L.) belongs to the family Cucurbitaceae and is grown throughout the world in both temperate and tropical climatic zones. It is commonly known as zucchini and is part of the gourd family. They are native to Central America and Mexico**.** Various cultivars of *Cucurbita pepo* are called summer squash, vegetable marrow, zucchini, and spaghetti squash (Purseglove, 1968).

In Bangladesh, this crop is relatively new but is increasingly gaining high levels of economical importance both in generation of income and provision of nutritional value. Squash has various health benefits to human as well as medicinal potentials (Mohammad *et al*., 2011). It is rich in nutrients and bioactive compounds contents such as phenolics, flavonoids, vitamins (including β-carotene, vitamin A, vitamin B_2, α- tocopherol, vitamin C, and vitamin E), amino acids, carbohydrates and minerals (especially potassium), and it is low in energy content (about 17 Kcal/100 g of fresh pumpkin) and has large amount of fiber (Tamer *et al*., 2010). It has various medicinal effects comprising anti-diabetic, anti-hypertensive, anti-tumor, anti-mutagenic, immunomodulating, anti-bacterial, anti-hypercholestero-lemic, intestinal anti-parasitic, antalgic, and anti-inflammation effects, and utilization possibilities of Cucurbitacious crops have been reported (Kostalova *et al*., 2009).

The key constraints to sustainable vegetable production are low moisture content, emergence of multiple nutrient deficiencies, low use and unbalanced use of fertilizers in soils (Shaheen *et al*., 2010). To conserve moisture content in soil, mulching treatment is a very important practice for successful crop production. Mulch is a preventive layer covering the surface of the soil and it contains organic and inorganic materials (Jafarnia and Homayi, 2006). Commercially, plastic mulches have been used for the production of vegetables since the 1960s (Lamont, 2005). The application of mulches helped the crop to mature 7-15 days earlier and it also contributed significantly to the plant's height, leaf area index, and dry matter, while the application of plastic mulch treatment improved the yield and efficiency of water usage in comparison to the mulch-free treatments (Zhao *et al*., 2012).

The practice of applying mulches to soil is possibly as old as agriculture itself. Mulches are used for various reasons but water conservation and erosion control are the most important objective for its use in agriculture in dry regions. Other reason for high mulching use includes soil temperature modification, soil conservation, nutrient addition, improvement in soil structure, weed control and crop quality control. Mulching reduces the deterioration of soil by the way of preventing the runoff and soil loss, minimizes the weed infestation and checks the water evaporation (Kumar and Lal, 2012). Mulching practice also conserves soil moisture, reduce infiltration rate, reduce fertilizer leaching, prevent from extremes of temperature, reduce weed growth and ultimately increase yield of crop (Bhardwaj, 2013). Thus, it facilitates more retention of soil moisture and helps in control of temperature fluctuations, improves physical, chemical and biological properties of soil, as it adds nutrients to the soil and ultimately enhances the growth and yield of crops.

In our country, the production of crops is constrained by low soil fertility due to continued cultivation without replenishment. This coupled with continued decline in soil fertility in most small holder farms due to little or no fertilizer application has led to reduction of crop yields (Kihanda, 1996). Farmers are using low quantities of organic fertilizers due to their limited quantities despite the government exertion to implement more sustainable agricultural practices by utilize locally available inputs that are less deleterious to the environment (Rodrigo *et al*., 2012). However, organic manures cannot meet crop nutrients' demand over large areas because of the limited quantities available, their low nutrients content and the high labour demands for processing and application (Palm *et al*., 1997). In this case, many farmers have resorted to the use of subsidised inorganic fertilizers such as (Urea - 46%N) since nitrogen fertilizers is important factor for vigorous growth due to its immediate availability to the plant roots and hence high yields (Mohamed *et al*., 2012). However, the use of excess nitrogenous fertilizers in production of vegetables leads to accumulation of nitrates beyond safe limits which have been shown to be detrimental to human health (Musa *et al*., 2010).

The aim of the investigation was to evaluate the effect of different mulch materials and nitrogen on growth and yield of squash. Considering above factors, the present study was undertaken with the following objectives:

1. To determine the suitable mulch materials for maximizing the vegetative growth and yield of squash;
2. To find out the optimum dose of nitrogen for better growth and yield of squash; and
3. To find out the better combination of mulch materials and nitrogen dose for ensuring higher growth and yield of squash.

CHAPTER II

REVIEW OF LITERATURE

Squash (*Cucurbita pepo* L.) is a popular vegetable crop of the world. Many research works have been done in different parts of the world to study the effect of different mulch materials and nitrogen on growth and yield of squash. But in Bangladesh, available literature regarding effect of mulch and nitrogen on squash is insufficient and sometimes conflicting. However, some of the literatures relevant to effect of mulch and nitrogen on squash production are reviewed in this chapter.

2.1 Literatures on mulching

Jha and Neupane (2018) conducted a field experiment at Olericulture Farm of Agriculture and Forestry University, Rampur, Chitwan, Nepal during April 29 to July 9 of 2018. The field experiment was carried out in split plot design using three replications. The treatments consisted of three intra row spacing (30, 45 and 60 cm) and four different mulching materials (Silver plastic, *Panicum repens*, *Lantana camara* and bare soil). The objective of this experiment was to assess the effects of various intra-row spacings and mulching materials on growth and yield of okra (*Abelmoschus esculentus*). The effect of mulching materials on okra yield was found significant. The okra yield was highest (8104 kg/ha) under silver plastic mulch followed by control (5161 kg/ha), *Panicum repens* (3901 kg/ha) and *Lantana camara* (3701 kg/ha), respectively. Silver plastic mulch enhanced the growth parameters like canopy length, plant height, leaf number, leaf length, girth and yield of okra. The spacings provided non significant effect on okra yield, however the yield of okra was highest (7295 kg/ha) under 30×30 cm spacing followed by 45×30 cm (4660 kg/ha) and 60 cm × 30 cm spacing (3703 kg/ha), respectively. Combination of silver plastic mulch along with 30 cm × 30 cm spacing provided the highest okra yield. This study suggested that farmers of the Chitwan should grow okra at spacing of 30 cm × 30 cm and under silver plastic mulch to produce higher yield.

Akhter *et al*. (2018) conducted a field experiment at the Horticultural Farm of Sher-e-Bangla Agricultural University, Dhaka during October, 2015 to January, 2016 to determine the effects of mulches and phosphorus on the growth and yield of squash (*Cucurbita pepo*). The experiment consisted of two factors. Factor A: different mulches and Factor B: phosphorus (3 levels). The experiment was laid out in a Randomized Complete Block Design with three replications. Mulches and phosphorus showed significant effects on most of the parameters. In case of mulches, highest individual fruit weight (328.0 g) and fruit yield (37.0 t ha^{-1}) was recorded from black polythene, whereas the lowest fruit weight (280.8 g) and fruit yield (21.5 t ha^{-1}) was recorded from control. In case of phosphorus, highest individual fruit weight (300.4 g) and fruit yield (31.3 t ha^{-1}) was recorded from 90 kg P_2O_5/ha, whereas the lowest fruit weight (290.4 g) and fruit yield (26.2 t ha^{-1}) was recorded from control. For combination, highest individual fruit weight (338.2 g) and fruit yield (39.9 t ha^{-1}) were recorded from black polythene with 90 kg P_2O_5/ha while the lowest individual fruit weight (272.2 g) and fruit yield (19.7 t ha^{-1}) were recorded from control treatment. Black polythene mulch with 90 kg P_2O_5/ha was found suitable for squash cultivation under the condition of the study.

Soleymani *et al*. (2015) conducted a study to determine the effect of mulch type (clear polyethylene mulch, black polyethylene mulch, hydro flume mulch, and no mulch), and planting method (seeded and transplanted) on cucumber, cv. Super Dominus. The interaction between mulch and planting method affected the number of days to flowering, plant length, number of days to harvest, and earliness. Early yield and yield per plant was highest (186.42 and 183.12 g/plant, respectively) when transplanting was with clear and black polyethylene mulch. Black mulch produced the highest total yield (1671.75 g) per plant. Clear mulch was most effective in controlling broomrape. Using polyethylene mulch (black and clear), and transplanting produced the highest early yield and mulch alone produced the highest yield and control of broomrape.

Azad *et al*. (2015) conducted an experiment to determine the effect of mulch on some characteristics of potato, a factorial experiment based on randomized complete block design with three replications was conducted in Asadabad, Hamedan (Iran). The experimental treatments consisted of mulch in five levels (clear mulch, white mulch, black mulch, double layer mulch and control, without mulch) and cultivar in two levels (Agria and Sante). The effect of mulch on the fresh and dry weight of weed was significant, so that the black and double layer mulches had greatest impact on reducing the fresh and dry weight of weed, respectively. As compared to control, clear mulch treatments could reduce the period of tuber formation by 6.33 days. Double layer mulches showed the highest number of stolons at 60-day after planting. In comparison to the control, mulch could reduce the days to harvest, while the clear (104.83 days), double layer (105 days), and white (105.16 days) mulches all had significant differences when compared to the control (108.16 days). Cultivar Sante and double layer mulch also had the greatest impact on early potato crop. Mulch was not, however, seen to have significant effect on yield per plant. Based on the overall results, cultivar Sante and double layer mulch are suggested for the purpose of further study in Asadabad, Hamedan.

Dalorima *et al*. (2014) carried out a study in the demonstration farm of Ramat Polytechnic Maiduguri in Nigeria to investigate the effects of different mulching materials on the growth performance of okra (*Abelmoschus esculentus* L.). The treatment include plastic mulch, sorghum straw mulch, sawdust mulch and control (No mulch) which were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The results show that growth parameter like plant height, weed count and flower bud count has no significant difference between the treatments but all treatment has some superiority to the control. It is evident from this work soil moisture retention was higher with the use of sorghum straw and polythene mulch and soil temperature was lowest in sorghum straw mulch.

Wang and He (2012) reported on two case studies on the effects of plastic mulching on potato growth in Northern China. Data from these experiments indicated that plastic mulching could save irrigation water and reduce evapo-transpiration in most cases. Daily mean soil temperature under mulch was 2–9°C higher than that without mulch, especially during the early growth stage. It was also reported that plastic mulch could restrain or enhance potato plant growth during the early growth, dependent on the micro-environmental air and soil temperatures. The possible negative effects of plastic mulching included a lower emergence, lower potato tuber yield, and poorer tubers quality, which may be attributable to the poorer soil aeration and detrimentally high soil temperature associated with plastic mulch when the air temperature is high.

Kumar and Lal (2012) observed that the mulching has been advocated as an effective means for conserving soil moisture. It works as an insulating barrier which checks evaporation from soil surface. Mulching is an agricultural and horticultural technique in which the use of organic materials (plant residues-straw, hay, groundnut hulls, leaf and compost, peat, wood products-saw dust and animal manures), and synthetic materials (paper, polyethylene, wax coated papers, aluminium, steel foils and asphalt spray emulsions etc.) with or without shallow tillage, for the purpose of increasing soil productivity is involved. This technique is very useful in protecting the roots of the plants from heat, cold or drought or to keep fruit clean. It checks evaporation and modifies the soil and air microclimate in which a plant is growing. Mulch is used to cover soil surface around the plants to create congenial condition for the growth. This may include temperature moderation, salinity and weed control. It exerts decisive effects on earliness, yield and quality of the crop. Mulching is also applicable to most field crops. However, it is preferred in fruit orchard, flower and vegetable production, nurseries and forest where frequent cultivation is not required for raising the crops. Most commonly used agricultural mulch is black plastic. Clear plastic mulch is used in some areas due to its increased soil warming characteristics. Weed control beneath the mulch is a deterrent to its use. White or aluminum reflective mulch is used where soil cooling is desired, such as establishing fall crops during the heat of summer. Research has shown that white or aluminum reflective mulch also repels aphids which spread some virus diseases in vine crops such as squash.

Zhang *et al*. (2009) carried out an experiment in a greenhouse at the Arid Land Research Center, Tottori University, Japan, using three weighing lysimeter to investigate the effect of gravel mulch (GM) and rice-straw mulch (RM) on the soil salinity, crop evapotranspiration (ET) and fresh and dry weight, yield and water use efficiency (WUE) of Swiss chard (*Beta vulgaris* L. var. flavescens) grown on Tohaku clay soil and irrigated with diluted seawater (6.86 dS/m). Three mulching treatments, control, rice-straw mulch (RM) and gravel mulch (GM) were compared. The study reported that the cumulative ET was higher with 'no mulch' control (292 mm) than under RM (254.7 mm) and GM (216.6 mm). Mulching generally increased the soil temperature slightly. RM treatment increased fresh matter yield by 76% and GM by 49% over control and similar trends were noted on dry matter. RM treatment increased WUE by 143 and 10% as compared to control and GM treatment, respectively.

Zaman *et al*. (2009) reported that the paddy straw mulches recorded higher yield in garlic than other mulches. The lowest yield was recorded when rice stubbles (50 cm height) were used as mulch. However, water hyacinth mulch also showed better performance but yield potentiality was 35.7% lower than paddy straw mulch.

Kumar and Sharma (2018) carried out an experiment at the department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara-144401, India on summer squash to investigate the effect of mulching on growth, yield and quality parameters in different varieties. The experiment was conducted with twenty different treatment combinations involving five different mulch materials (black plastic mulch, blue plastic mulch, transparent mulch, rice straw mulch and control) and four different varieties of summer squash (Arpit, Surya, Pratap and Desi) following Split Plot Design with three replications. From the observations recorded, Black plastic mulch showed significant improvement in growth and yield of summer squash, while among the varieties “Surya” produced greater yield than others. Based upon the studies, commercial cultivation of summer squash, ‘Surya’ variety gave the highest yield under black plastic mulch.

Sarkar *et al*. (2007) analyzed mulches keep the soil cooler in the summer and warmer in the winter, thus maintaining a more even soil temperature. They reported that higher yield and better crop growth were observed in the mulched plots, which might be due to conservation of soil moisture and reduction of soil temperature by 4-6 degrees C. The highest PAR (89% of the PAR incident above the crop canopy) was found near the crop with mulching and four irrigations. Application of straw mulch significantly increased the available phosphorus and potassium in the soil. Water use efficiency and tuber productions differed significantly among irrigation treatments in the non mulched plots but they did not in the mulched plots with three and four irrigations. Therefore, three irrigations of 75 mm each and mulching were recommended for growing potato in the region when limited water was available.

Dahiya *et al.* (2007) studied the straw mulching effects on soil temperature of a soil during August to September and reported that the application of wheat straw mulch reduced average soil temperature by 0.74, 0.66, 0.58 degrees C at 5, 15 and 30 cm depth respectively as compared with the control.

Jamil *et al*. (2005) observed the effects of different type of mulches (plastic, straw & sawdust, excluding, control) and their duration (one month & whole season) on the growth and yield of garlic in a field experiment. Straw and plastic mulches increased the bulb yield and yield components, irrespective of their duration. Straw mulch is recommended for the garlic production based on better overall performance than the others and also for being cheaper and organic in nature.

Crusciol *et al*. (2005) reported that straw of covering plants kept on soil surface in no-tillage system is an important source of nutrients for subsequent tillage. This study investigated the decomposition and release of macronutrients from forage turnip residues. The experiment was set under field conditions during 1998 in Marechal Candido Rondon, Parana, Brazil. Forage turnip plants were desiccated and lodged 30 days after emergence. Straw persistence and nutrient release were evaluated at 0, 13, 35, and 53 days after management. Untill per- flowering stage, the crop turnip showed a high dry matter yield (2938 kg/ha) during winter, and accumulated 57.2, 15.3, 85.7 and 14.0 kg/ha of N, P, K, Ca, Mg and S, respectively. Forage turnip management at pre-flowering stage resulted a quick straw degradation and macronutrients release. Potassium and N were released in the highest amounts and in the shortest time to subsequent tillage. The fastest liberation of nutrients occurred between 10 and 20 days after plant management.

Hashem (2005) carried out an experiment on effects of manuring and mulching on growth and yield of broccoli in Bangladesh Agricultural University, Mymensing and observed that the maximum average yield (17.6 t/ha) was obtained from organic and inorganic fertilizers with black polythene mulch.

Bhatt *et al*. (2011) conducted a field experiment in order to find out the effect of different mulch materials viz., black plastic, clear plastic, dry leaves, pine needles, green twigs of non fodder plants, forest litter and F.Y.M. on vegetative characters, yield and production economics of summer squash, the field experiment were undertaken during spring - summer season of 2009 and 2010 under rainfed mid-hill condition of Uttarakhand. The maximum plant height (38.11 cm), plant spread (142.39 cm), number of leaves per plant (41.85), root length (36.83 cm) and yield (62.72 t/ha) were recorded in black plastic mulch when compared with other treatments. The black plastic mulch not only advanced the harvesting time but also produced 74.17 per cent higher fruits yield than the control. Amongst the organic mulches, pine needles and forest litter were found equally effective in improving vegetative characters, which ultimately resulted in higher yields. Mulching with black plastic in summer squash was also found most economical with a net return of TK. 232628.70 ha-1 and Cost ratio of 2.61.

Faruque (2004) carried out an experiment on effects of different sources of nutrients and mulching on growth and yield of broccoli in Bangladesh Agricultural University, Mymensing and observed that the maximum average yield (18.2 t/ha) was obtained from organic + inorganic fertilizer with black polythene mulch while minimum yield was given by (no fertilizer + no mulch +irrigation) treatment.

Bhuiyan (2003) conducted a field experiment at the Horticulture Farm of Bangladesh Agricultural University, Mymensingh during the period from November 2002 to March 2003 to investigate the effect of mulching, variety and crop management practices on growth and yield of potato. The experiment was conducted with four mulching treatments, (no mulch no irrigation, irrigation, saw dust and straw mulch); two varieties (‘Diamant’ and ‘Cardinal’) and use of organic manure without pesticides application). Mulching treatments showed significant effect on most of the yield and yield components. The highest yield (21.31 t/ha) was obtained from straw mulch followed by sawdust (19.47 t/ha), irrigation treatment (19.06t/ha) and no mulch no irrigation treatment (15.29t/ha). The variety also caused significant variations on most of the parameters. The variety Diamant gave the higher yields (19.07 t/ha) and compare to Cardinal (18.51 t/ha) yield.

Santos *et al*. (2003) carried out an experiment with broccoli cultivars Baron, Shigimori and pinacco and found that the fresh mass of broccoli heads due to cultivation were not significant except for Shigimori which recorded higher fresh mass when cultivated in open fields. The number of leaves per plant was higher under open field cultivation of Shigimori and pinacco and under non-woven propylene cultivation of Baron. The longitudinal diameters of all the 3 cultivars were higher under open field cultivation compared to cultivation under non-woven propylene. The transverse diameters of broccoli were higher under open field cultivation for Baron and Shigimori and under non-woven propylene cultivation of pinacco.

Runham *et al*. (2000) reported that paper mulch increased soil moisture levels in non-irrigated courgettes but not in irrigated celery compared to non-covered soil. They also found that both paper and plastic mulches gave similar or higher mean head weight in broccoli. From another experiment they concluded that soil temperature beneath the paper mulch was lower than both the non-mulched and black polythene covered plots. Chowdhury *et al.* (2001) conducted a field experiment in the rabi season of 1997-1998 on a clay terrace soil in Salna, Gazipur, Bangladesh, to study the effect of rice straw mulching and irrigation on the yield total water use and water use efficiency of an indigenous low yielding cultivar of potato, Lalpakri. Irrigation is indispensable in the rabi season of Bangladesh and the yield was significantly lowest in the treatment of no irrigation after seedlings establishment. Rice straw mulch conserved soil moisture and maintained a higher moisture regime in each irrigation level through the cropping period. The treatments of rice straw mulching and the single irrigation at 30 days after sowing were the best combination with a satisfactory high yield.

Campigila *et al*. (2000) studied the effect of mulches and observed that mulching with polythene increased the soil temperature at all depths compared with non-mulched soil. They also reported that mulch significantly reduced weed density (70%) but not the weed biomass compared with the control. In case of cauliflower, yield was improved by 47% over black polythene mulch compared with the control.

Collins (1997) reported that transparent black polythene and polythene coated black paper mulches increased soil temperature and advanced emergence of potato. He also reported that transparent black polythene and polythene coated black paper mulches non significantly reduced the yield of potato from bare soil of 46.9 and 48.3 t/ha and clear polythene mulch.

Coolong (2010) conducted a field experiment in Fall 2007 and Spring 2008 to evaluate the performance of paper mulches for the production of summer squash (*Cucurbita* *pepo* ssp. *ovifera*) 'Conqueror III'. Four paper mulches, 50-lb kraft paper, 50-lb polyethylene-coated kraft paper, 40-lb white butcher paper, and 30-lb waxed paper were compared with 1-mil black polyethylene mulch, bare-ground hand-weeded, and bare-ground nonweeded treatments. In Fall 2007, butcher paper and polyethylene-coated kraft paper controlled weeds as well as black plastic mulch. However, in Spring 2008, black plastic mulch provided superior weed control compared with other mulches. Yields among waxed, butcher, and polyethylene-coated kraft papers were similar to black plastic mulch in 2007, though yields in paper mulch plots were significantly less than plastic mulch in spring, 2008.

Jalil (1995) conducted an experiment at the Horticulture farm, Bangladesh Agricultural University, Mymensingh in order to study effect of mulch on potato. Black polythene mulched potato took minimum time to reach 80% emergence, resulted maximum coverage of area. However, yield was higher with water hyacinth mulch.

Khalak and Kumaraswamy (1992) conducted a field trial in 1985- 1987 on red sandy soil at Bangalore, karantakca. Potatoes cv. Kufrijyoti was irrigated with 20 or 40 mm water and the crop was given no mulch, straw mulch or polythene mulch. Tuber yield and N uptake were the highest in both years with 20mm irrigation water. Mulching with straw and polythene gave average tuber yields of 18.2 and 16.7 t/ha respectively compared with 14.3 t/ha without mulching.

Bobby *et al*. (2017) reported that among the different mulches i.e Black- black, Black-silver, Black-white, organic mulches like paddy straw, paddy husk, ground nut shells and pre-emergence herbicide (pendimithaline @ 1.0 kg a.i/ha-1) on weed control study showed significant differences on weed density and weed dry weight were the lowest with the use of Black-black polythene mulch whereas control recorded the highest weed density and weed dry weight at 30, 60 and 80 days after sowing respectively. Highest weed control efficiency (92.12%, 91.38% and 91.01%) was registered with

Black-black polythene mulch whereas lowest weed control efficiency (55.93%, 56.02% and 56.88%) was registered with paddy straw mulch at 30, 60 and 80 DAs respectively. Weed index (74.83%) was significantly highest in Pre-emergence herbicide (Pendimithaline @ 1.0 kg a.i. ha^{-1}), while lowest (3.65%) Weed index was registered with Black-silver polythene mulch.

2.2 Literatures on nitrogen

Naderi *et al*. (2017) conducted a study to evaluate the growth and yield of pumpkin *(Cucurbita pepo* L.) under different nitrogen rates and to determine the nitrogen use efficiency (NUE) of pumpkin in two growing seasons (2013 and 2014). In both growing seasons, nitrogen fertilizer (at three rates including 50, 150, and 250 kg ha^{-1}) was band-dressed on the planted side of each furrow, coinciding with 4-6 leaves stage and flowering. Crop performance over 2 years was evaluated by measuring shoot dry matter, crop growth rate (CGR), leaf area index (LAI), leaf area duration (LAD), intercepted PAR, radiation use efficiency (RUE), shoot nitrogen uptake, water use efficiency (WUE), NUE, and fruit and seed yield. The results showed that in both growing seasons, the highest growth and yield of pumpkin were obtained by applying 250 kg N ha^{-1} (using urea fertilizer containing 46% nitrogen). Increased nitrogen rate from 50 to 250 kg ha^{-1} resulted in 87.3%, 27.0%, 62.1%, 87.5%, and 84.5% increase in shoot dry weight, RUE, WUE, fruit yield, and seed yield of pumpkin, respectively, across both growing seasons. However, higher applic ation nitrogen rate decreased the NUE of pumpkin, i.e., the NUE decreased by 62.5% when the nitrogen rate increased from 50 to 250 kg ha^{-1}. The effect of nitrogen applied in 2014 growing season on growth and yield of pumpkin was higher than that in 2013 growing season, which might be due to more suitable weather condition. In conclusion, the nitrogen rate of 250 kg ha^{-1} produced the highest amount of fruit and seed yield in pumpkin.

Wahocho and Maitlo (2017) carried out a study to evaluate the effect of various nitrogen applications on the economic performance of muskmelon. Nitrogen fertilization at higher rates enhances the yield of crop plants; however, overuse of N in cultivation of crop not only decreased nitrogen use efficiency of crop plants but caused severe environmental pollution. Hence, the optimum use of N is prerequisite for sustainable development of agriculture. This research work was laid out at experimental site of Horticulture orchard, Sindh Agriculture University, Tandojam in Pakistan with three replications in RCBD. The growth and yield performance of muskmelon was assessed by using six nitrogen (N) levels viz; 0, 30, 60, 90, 120 and 150 kg ha^{-1}. Two varieties including Chandny and golden tumbro were used in the current study.The result showed that effect of different nitrogen doses on the economic important parameters of muskmelon was significant for all the studied traits. The crop fertilized with maximum level of N had positive effect on vegetative traits and produced tallest plants with more branches. Nitrogen also showed significant effects on fruits characteristics and produced plants with more fruits, highest weight and maximum yield. The results further reflected that there was a significant reduction in all vegetative and fruit contributing characters with each reduction in N application rate. The cultivars revealed a highly significant response to various N doses. The variety Golden Tumbro showed maximum vine length (201.00 cm), more branches $vine^{-1}$ (3.4222), more fruit $vine^{-1}$ (6.7339), highest fruits weight $vine^{-1}$ (3.0056), maximum single fruit weight (656.83 g), fruit yield $plot^{-1}$ (4.4450 kg) and fruit yield (24.635 t ha^{-1}).

Sabreen *et al*. (2015) carried out an experiment during two successive summer seasons of 2012/2013 and 2013/2014 at El-Khattara Experimental Farm, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt, to study the effect of nitrogen fertilization and foliar spray with chitosan on growth, yield and fruits quality of summer squash plants grown in sandy soil. This experiment included nine treatments which were the combinations between three rates of nitrogen (45, 60 and 75 kg /feddan) and three concentrations of chitosan (0.0 , 0.05 and 0.10g /l). The results revealed that the fertilization of summer squash plants with N at 75 kg/feddan significantly enhanced plant growth characters, yield and its components, and nutrients (N, Fe, Cu, Mn and B). While, T.S.S.(%), P and K contents in fruits were not significantly affected. Moreover, spraying with chitosan at 0.10g/l significantly increased plant growth characters, yield and its components, T.S.S.%, N and P. On the other hand, it decreased Fe, Zn, Cu and B content in fruits. In addition, the interaction treatments between N at 75 kg/feddan and spraying plants with chitosan at 0.10g/l gave the highest values of plant growth, yield and its components, N as well as P content in summer squash fruits.

Ngetich *et al*. (2013) stated that zucchini (*Cucurbita pepo* L.) is a newly introduced crop and is increasingly becoming an economically important vegetable crop in Rwanda despite of its low production due to insufficient or no fertilizer application. In view of this, they conducted a field research at Higher Institute of Agriculture and Animal Husbandry (ISAE), Northern Province, Rwanda with the aim of determining the optimum nitrogen rate (Urea 46%) that could maximize zucchini productivity. Two experiments in a Randomized Complete Block Design with five treatments (0, 40, 80, 120 and 160 kg N ha^{-1}) replicated four times were set up from September to November in 2011 and 2012. The parameters assessed were vegetative characteristics, yield and soil characteristics. The growth was significantly ($p < 0.05$) affected by nitrogen nutrition. Plants subjected to 160 kg N ha^{-1} exhibited increase of about 22.9 - 55.9% in plant height; 28.0 - 29.4% in stem diameter; 26.6 - 39.7% number of leaves; 61.0 - 204.1% leaf area and 103.2 - 235.2% leaf area index compared to the control. Male and female flowers from plants subjected to 120 kg N ha^{-1} were more by between 13.9 - 30.8% and 7.5 - 63.5% respectively in contrast to the control. Biomass yield from 120 and 160 kg N ha^{-1} was 15.9 t ha^{-1} and about 99% higher than the control. Maximum yield was realised from plants subjected to 120 kg N ha^{-1} which averaged at 11.3 t ha^{-1} and 86.0% higher than the control.

Zaman *et al*. (2011) conducted experiments for two consecutive rabi seasons of 2005-06 and 2006-07 at the Regional Agricultural Research Station (RARS), Jamalpur to find out an optimum dose of nitrogen for the production of garlic (cv. Jamalpur local). There were six levels of nitrogen viz., 0, 50, 100, 150, 200, and 250 kg/ha. The experiment was laid out in randomized complete block design with three replications. Results revealed that nitrogen had significant effects on almost all the parameters studied. Nitrogen @150 kg/ha produced the highest bulb yield (6.75 t/ha in 2005-06 and 7.19 t/ha in 2006-07) and there was a reduction of yield with further increment of nitrogen level. The control treatment receiving no fertilizer produced the lowest bulb yield in both the years. The yield benefit for 150 kg N/ha was 40% than the yield obtained from nitrogen control treatment when average of two years' yield is considered.

Mohamed *et al*. (2010) conducted a field experiment during the two successive seasons of 2006 and 2007 at the experimental station of National Research Centre at Shalakan to study the response of squash plant to the foliar spraying (two and three times) of some nutrients (N + Ca, N + K, N + Zn and N only plus control treatments). The three times of foliar application with macro and/or microelements gained the vigour plant growth of squash expressed by length of plant and leaves, average vines and/or leaves per plant, whole fresh and dry weights of plants and their different organs. Also, the total and early fruits yield as well as its physical properties and chemical nutritional values gained when 3 times of foliar application of nutritional fertilizer were applied. The obtained results reveal that the best plant growth measurements of squash were recorded when nitrogen (urea 1.5 %) + potassium (potassium thio sulphate, 36.5 K_2O) and/or nitrogen + calcium (Calborate, 14 % Ca) were applied as a foliar application. Whereas, the differences within these two treatments were no great to be significant. Also, the total and early fruits yield of squash and its physical properties (fruit length, diameter and weight) as well as the nutritional values of fruits (protein, N, P, K, Fe, Zn Cu and Mn). All of these measurements recorded their highest values when plants were sprayed by nitrogen + potassium and/or nitrogen + calcium.

Tlustos *et al*. (2002) investigated in pot experiment to know the effect of slow release N fertilizers and urea with three vegetables (radish cv. Duo, lettuce cv. Detenicka and carrot cv. Nantes) and two rates of applied N. Directly fertilized radish, subsequently grown unfertilized lettuce and third crop directly fertilized carrot were treated by urea as control treatment and by three samples of slow release fertilizers based on urea formaldehyde condensate of different solubility. Availability of N from slow release samples affected yield of growing vegetables and their nitrogen uptake. Lower availability of N caused lower yields of radish and subsequently grown lettuce mainly on treatments with lower rate of fertilizer compared with urea treatments. Carrot planted as a third vegetable and directly treated by nitrogen showed higher yield at treatments with less soluble samples due to longer growing period and continuing release of N from slow soluble samples. Yield of dry matter of individual vegetables correlated well with uptake of nitrogen determined by balance and isotope methods. Among both isotope techniques introduced, about twice lower utilization than the balance method probably caused by priming effect of N and by unsuitable conditions for plant growth at unfertilized zero treatment.

Salomez and Hofman (2009) carried out an experiment to examine the dependence of butterhead lettuce crops' nitrate concentration on soil mineral nitrogen (N) content. It was shown that the effect of the soil's mineral N content at harvest was strongly associated with the nitrate concentration of lettuce at a low to intermediate mineral N content (<100 kg N ha^{-1}). This demonstrates the importance of N fertilization practices. A lower N application at either recommendation resulted in 71% of the experiments (17/24) having a lower leaf nitrate concentration. The head weight was negatively affected in only 2 of these 17 experiments. Minimizing the N input and hence lowering the soil N content at harvest points to the possibility of further reducing the nitrate concentration level in greenhouse lettuce, while having no significant negative effect on economic yield.

Matsumoto *et al*. (2001) studied on comparing the nitrogen (N) uptake of four different kinds of vegetables, i.e., pimento (*Capsicum annuum*), leaf lettuce, chingensai (a kind of Chinese cabbage, *Brassica pekinensis*), and carrot, from soil to which rapeseed cake (RC) or ammonium sulfate (AS) had been applied at the same N concentration, different N uptake responses were observed. Chingensai and carrot took up more N from the soil with applied RC than with applied AS. On the other hand, pimento and leaf lettuce grew better on the soil with applied AS than on that with applied RC. In xylem sap of chingensai grown in the soil with applied RC, a peak similar to the protein-like N compound in soil was detected on the HPLC chromatogram. Further, when chingensai, carrot, and pimento were cultivated in an N-free medium under aseptic conditions, the N uptake of chingensai and carrot increased with the addition of protein like N compound extracted from the soil. These results strongly suggest that the superior N uptake response after application of organic material by chingensai and carrot may be related to the direct uptake of organic N from the soil.

Rehman *et al*. (2001) studied the effect of sowing dates (8, 18 and 28 October and 8 November 1998) and nitrogen levels (0, 20, 40, 60 and 80 kg/ha) on the leaf yield of lettuce cv. Crinkle, an experiment was conducted at Horticulture Farm, NWFP Agricultural University Peshawar, Pakistan, during winter 1998- 99. Leaves per plant, leaf area and leaf yield per hectare were significantly affected by sowing dates. Maximum leaves per plant (13.66), leaf area (73.64 cm^2) and yield/ha (12.3 t) were recorded in plots sown on 18 October. Nitrogen application at the rate of 80 kg/ha significantly affected leaves per plant, leaf area, leaves weight and yield per hectare. Maximum number of leaves per plant (14.88), leaf area (83.83 cm^2), leaves weight (17.19 g/plant) and yield/ha (13.6 t) were noted in plots which received nitrogen at the rate of 80 kg/ha compared to other levels of nitrogen.

Grazia *et al*. (2001) evaluated the effect of light radiation and temperature on the growth patterns of a leafy lettuce cultivar and their interaction with fertilizer application through trials which combined three shade levels (65, 35, and 0%) with three fertilizer application rates (0, 75 and 150 kg N/ha) in a winter sowing date. The same fertilizer application rates were applied to unshaded crops sown in the spring season. Growth rate, yield and quality traits of lettuce were measured. The results showed that radiation level was the most important factor controlling growth in lettuce, whereas the effect of N fertilizer application was only observed in those treatments in which light intensity was not a limiting factor. Results indicated that N fertilizer application rates higher than 75 kg N/ha do not provide any significant benefit to leafy lettuce crops under open field conditions neither in winter nor in spring sowing dates.

Mohammad (2004) conducted a field experiment to evaluate squash yield and nutrient content in response to different fertigation nitrogen rates and method of N fertilizer application. Four treatments were studied in a randomized complete block design with four replications: zero N (N_0), 50 (N_1), 100 (N_2) and 150 (N_3) mg l^{-1} N concentration in the irrigation water as fertigation treatments and a soil application treatment equivalent to the N_2 treatment. Compared to the control (N_0), shoot dry matter and yield were increased by all fertigation N rates and by the soil application treatment. However, soil application gave a lower yield than the equivalent fertigation N rate, indicating the comparative advantage of fertigation. The lowest fertigation N rate was adequate to give the highest yield in the first season, while in the second season a higher rate was necessary to achieve the maximum yield. The growth and fruit yield were higher in the second season as a result of the more favorable climatic conditions. The fruit yield was linearly related to both fruit number and fruit size in both seasons. N contents in shoots increased with N addition and were higher in both fruit and shoot during fruiting with the fertigation method. Soil salinity slightly increased with N application, especially in the top 15 cm, but remained low and acceptable for normal plant growth. Results indicated that fertigation is more effective than soil application in increasing the yield of squash and with fertigation lower nitrogen rates would be adequate to produce higher yield, thus lowering fertilization cost and minimizing environmental impact of over-fertilization.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2017 to February 2018 to study the effect of mulch materials and nitrogen on growth and yield of squash. The details of the materials and methods have been presented below:

3.1 Experimental location

The present piece of research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. The details of morphological and chemical properties of initial soil of the experiment plot were presented in Appendix II.

3.3 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris *et al.*, 1979). Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix III.

3.4 Planting material

The vegetable crop; squash was considered for the present study. Seeds of First Runner F_1 Hybrid Squash variety was used.

3.5 Experimental details

3.5.1 Treatments

The experiment comprised of two factors.

Factor A: (Mulch materials) – Three types

1. M_0 = No mulch (Control)
2. M_1 = Straw mulch
3. M_2 = Black polythene

Factor B: (Nitrogen) – Four levels

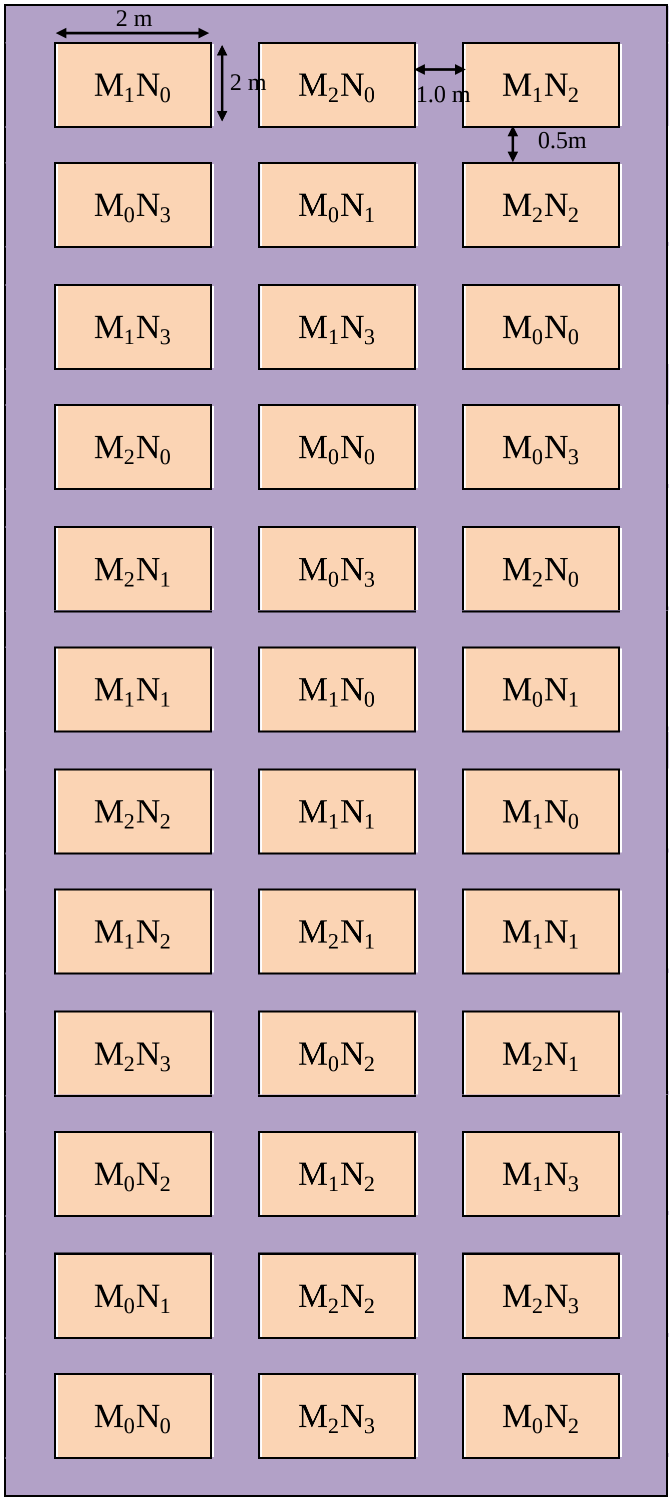
1. N_0 = 0 kg N ha^{-1} (Control)
2. N_1 = 80 kg N ha^{-1}
3. N_2 = 130 kg N ha^{-1}
4. N_3 = 180 kg N ha^{-1}

Treatment combinations – Twelve (12) treatment combinations were as follows:

M_0N_0, M_0N_1, M_0N_2, M_0N_3, M_1N_0, M_1N_1, M_1N_2, M_1N_3, M_2N_0, M_2N_1, M_2N_2 and M_2N_3.

3.5.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of mulching and different nitrogen levels. The 12 treatment combinations of the experiment were assigned at random into 36 plots. The size of each unit plot 2 m × 2 m (= 4 m^2). The distance between blocks and plots were 1.0 m and 0.5 m respectively.



Legend:

Plot length : 2 m

Plot breadth : 2 m

Plot size : (2×2) m^2

Plot to plot distance : 0.5 m

Block to block distance: 1.0 m

Fig. 1. Layout of the experiment field

3.6 Raising of seedlings

3.6.1 Preparation of polybags

Seeds were sown in polybags which were filled with loose friable, dead roots free, sandy loam soil previously mixed with well rotten cowdung. The soil was treated by Sevin 50WP @ 5kg/ha to protect the seed and young plants from the attack of ants. Size of the polybags was (8×8) inches.

3.6.2 Seed treatment

Seed treatment was done by vitavax @ 3 g/kg seeds to prevent some seed borne diseases.

3.6.3 Seed sowing

The polybags were kept in the bed for raising the seedlings. Seeds were sown in the polybags on 30 October, 2017. Each polybag contained two seeds of squash. After sowing, the seeds were covered with light soil. watering was done by water cane regularly. Complete germination of the seeds took place with 5 days after seed sowing. Necessary shading was made by white polythene to protect the seedlings from scorching sunshine or rain. No chemical fertilizer was used in the polybags.

3.7 Preparation of the main field

The plot selected for the experiment was opened in the first week of November, 2017 with a power tiller and was exposed to the sun for a few days, after which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for transplanting. The land operation was completed on 13 November 2017. The individual plots were made by raising soil (20 cm high) from the ground level.

3.8 Fertilizers and manure application

The N, P, K fertilizer were applied according to Krishi Projukti Hat Boi (BARI, 2015) through urea, Triple super phosphate (TSP) and MoP respectively. Cowdung also used as organic manure. Nitrogen (N) was applied through urea as per treatment. Nutrient doses used through fertilizers under the present study are presented as follows:

Nutrients	Manures/fertilizers	Doses ha^{-1}
-	Cowdung	10 ton
N	Urea	As per treatment
P	TSP	170 kg
K	MoP	150

Full amount of TSP, MoP, and well rotten cowdung were applied at the time of final land preparation following some research work on squash was done in abroad and BARI recommendation for cucurbitaceous crop. Urea was applied in two equal installments at 25 and 35 days after transplanting (DAT), respectively.

3.9 Application of mulch materials

Two types of mulch materials; viz., black polythene and rice straw mulch were used**.** The rice straw was chopped into small pieces and sun dried for two days before placing and black polythene sheet with small opening which was made for maintaining proper plant to plant distance before placing over the plots. The rice straw mulch was provided at 5 cm thick approximately.

3.10 Transplanting of seedlings

Healthy and uniform sized 15 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field on 14 November, 2017. 1m × 1 m plant spacing was maintained for transplanting. The poly bags were was watered before uprooting the seedlings so as to minimize the damage of the roots. The bags were cut with a sharp knife so that tender seedlings could be planted with adjacent root soil. This operation was carried out during late hours in the evening. The seedlings were watered after transplanting.

3.11 Intercultural Operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of squash.

3.11.1 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gaps filling were done by healthy plants from the border whenever it was required. Weeds of different types were controlled manually as and when necessary.

3.11.2 Irrigation

Light irrigation was given immediately after transplanting around each seedling for their better establishment. Watering was done up to five days until they become capable of establishing on their own root system. Irrigation was given by observing the soil moisture condition.

3.11.3 Plant protection

The insects were controlled successfully by spraying Malathion 57 EC @ 2ml /L water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting.

3.12 Harvesting and cleaning

Fruits were harvested during maturity stage. Harvesting was started from 24 December, 2017 and completed by 26 January, 2018.

3.13 Data collection

The data pertaining to following characters were recorded from four plants from each plot except yield of fruits which was recorded plot wise.

3.14 Procedure of recording data

3.14.1 Stem length

The stem length was recorded in centimeter (cm) at different days after transplanting of crop duration with a meter scale. Data were recorded from each plot. The length was measured from the ground level to the top of the stem using meter scale. Data were taken at 15, 30 and 45 days after transplanting (DAT).

3.14.2 Number of leaves plant^{-1}

Number of leaves per plant was counted at different days after transplantig of crop. Leaves number per plant was recorded from each selected plants of each plot and mean was calculated. Data was taken at 15, 30 and 45 days after transplanting (DAT).

3.14.3 Leaf length

Leaf length was measured by using a meter scale. The measurement was taken from base of leaf to tip of the petiole. Average length of leaves was taken from five random selected leaves from each plant from each plot. Data was recorded from 15, 30 and 45 days after transplanting (DAT). Mean was expressed in centimeter (cm).

3.14.4 Leaf breadth

Leaf breadth was measured by using a meter scale. Average breadth of leaves was taken from five random selected leaves from each plant from each plot. Data was recorded from 15 to 45 DAT at 15 days interval. Thus mean was recorded and expressed in centimeter (cm).

3.14.5 Stem base diameter

Diameter of stem base in centimeter (cm) was recorded from each plants of each plot at different days after transplanting (at 15, 30 and 45 DAT) at the base portion of the plant with a slide calipers. The average value is termed as stem base diameter.

3.14.6 Days to 1st flowering

Days to first (1st) flowering was recorded from the date of transplanting to when first flower is appeared in each plant and the average value was calculated.

3.14.7 Number of female flower

Number of female flowers was counted from each plant of each plot and mean was calculated. Female flowers were selected based on the presence of initial oval shape fruit like structure at the base of flower.

3.14.8 Number of male flower

Number of male flowers was counted from each plant of each plot and mean was calculated. Male flower selected based on the absence of initial oval shape fruit like structure at the base of flower.

3.14.9 Percent (%) dry matter of leaf

Fresh 100 g sample of leaves from each plot were taken. At first it was sundried and then placed in oven maintained at temperature 70^0 C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The average dry weight of the leaf sample was taken and percent (%) dry matter of leaf was calculated by the following formula:

$$\text{percent (\%) dry matter of leaf} = \frac{\text{Dry weight of leaf (g)}}{\text{Fresh weight of leaf (g)}} \times 100$$

3.14.10 Percent (%) dry matter of fruit

Fresh 100 g sample of fruit from each plot were taken. At first it was sundried and placed in oven maintained at temperature 70^0C for 72 hours. The samples were then transferred into desiccators to dry them and allowed to cool down at room temperature.

The average dry weight of the samples was taken and percent (%) dry matter of fruit was calculated by following formula:

$$\text{percent (\%) dry matter of fruit} = \frac{\text{Dry weight of fruit (g)}}{\text{Fresh weight of fruit (g)}} \times 100$$

3.14.11 Fruit length

The length of the fruit was measured with a meter scale in centimeter from the neck of the fruit to the bottom of the fruit. It was measured from each plot and their average was calculated in centimeter.

3.14.12 Fruit diameter

The diameter of individual fruit was measured in several directions from five selected fruits with slide calipers and the average of all directions was finally recorded and expressed in centimeter (cm).

3.14.13 Number of fruits plant^{-1}

Total number of fruit was counted from each plant of each plot from first harvest to last harvest and average number of fruit was calculated and termed as number of fruits per plant.

3.14.14 Single fruit weight

From first harvest to last harvest total fruit number was counted and total fruit weight was measured from each plant of each plot to determine single fruit weight. Single fruit weight was calculated from total fruit weight dividing by total number of fruits.

3.14.15 Fruit yield plot^{-1}

Total fruit was collected from 1st harvest to last harvest from each plot and weighed. The total weight was considered as fresh fruit yield per plot and expressed in kilogram (kg).

3.14.16 Fruit weight ha^{-1}

After collection of fruit per plot, it was converted to ton per hectare by the following formula:

$$\text{Fruit yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg)} \times 10000\ m^2}{\text{Plot size } (m^2) \times 1\,000\ \text{kg}}$$

3.15 Statistical Analysis

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

3.16 Economic analysis

Economic analysis was done to find out the cost effectiveness of different treatments like different levels of mulching and nitrogen in cost and return were done in details according to the procedure of Alam *et al*. (1989).

3.16.1 Analysis of total cost of production

All the material and non-material input cost, interest on fixed capital of land and miscellaneous cost were considered for calculating the total cost of production. Total cost of production (input cost, overhead cost), gross return, net return and BCR are presented in Appendix XIII.

3.16.2 Gross income

Gross income was calculated on the basis of marketable fruit sale. The price of squash was assumed to be Tk. 15/kg basis of current market value of farmer level, at the time of harvesting.

3.16.3 Net return

Net return was calculated by deducting the total production cost from gross income for each treatment combination.

3.16.4 Benefit cost ratio (BCR)

The economic indicator BCR was calculated by the following formula for each treatment combination.

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross income per hectare}}{\text{Total cost of production per hectare}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to find out the effect of different mulch materials and nitrogen on growth and yield of squash. Data on different growth, yield contributing characters and yield were recorded. The results of the analyses of variance (ANOVA) on different recorded parameters have been presented in Appendix IV-XII. The findings of the experiment have been presented and discussed with the help of table and graphs and possible interpretations were given under the following headings:

4.1 Growth parameters

4.1.1 Stem length

There was a significant variation on stem length at different growth stages influenced by different mulching treatment (Appendix IV). Results revealed that the highest stem length (10.44, 22.61 and 36.56 cm at 15, 30 and 45 DAT) was found from the mulching treatment M_2 (Black polythene) followed by M_1 (Straw mulch). The lowest stem length (9.53, 20.89 and 33.04 cm at 15, 30 and 45 DAT) was found from the control treatment M_0 (Fig. 2). As plastic mulches conserve soil moisture, vegetative growth improvement might be explained in view of it. Dalorima *et al*. (2014) concluded that plastic mulch, sorghum straw mulch, sawdust mulch treatment resulted in higher plant height than non-mulched treatment in case of okra (*Abelmoschus esculentus* L.). Kumar and Sharma (2018) also observed similar result in case of summer squash which supported the present study.

Stem length at different growth stages was significantly influenced by different nitrogen levels (Appendix IV). It was observed that the highest stem length (10.19, 22.33 and 37.02 cm at 15, 30 and 45 DAT) was found from the N treatment of N_3 (180 kg N ha^{-1}) which was statistically identical with N_2 (130 kg N ha^{-1}). The lowest stem length (9.33, 20.19 and 31.41 cm at 15, 30 and 45 DAT) was found from the control treatment N_0 (Fig. 3). It revealed that the stem length increased with the increased in level of nitrogen application as well. Significant variation was found as nitrogen is considered as the most important component for supporting plant growth. Nitrogen is a constituent element of many vital organic compounds like chlorophylls, amino acids (protein building block), cytochromes, alkaloids and some vitamins and thus plays a very important and fundamental role in metabolism, growth and reproduction. The result obtained from the present study was consistent with the findings of Ngetich *et al*. (2013) who reported that plant height increased with the increase in nitrogen level. Wahocho and Maitlo (2017) found the similar results in musk melon.

Significant variation was observed on stem length at different growth stages influenced by combined effect of mulching and nitrogen (Appendix IV). Results signified that the highest stem length (11.22, 24.56 and 40.17 cm at 15, 30 and 45 DAT) was found from the treatment combination of M_2N_3 which was statistically identical with M_2N_2 at 45 DAT. The lowest stem length (9.00, 19.89 and 30.00 cm at 15, 30 and 45 DAT) was found from the treatment combination of M_0N_0 followed by the treatment combination of M_1N_0 and M_2N_0 at 45 DAT (Table 1).

4.1.2 Number of leaves plant^{-1}

Different mulching treatment had significant influence on number of leaves plant^{-1} at different growth stages (Appendix V). The highest number of leaves plant^{-1} (6.75, 12.75 and 22.28 at 15, 30 and 45 DAT) was found from the mulching treatment, M_2 (Black polythene) which was significantly different from other treatments. The lowest number of leaves plant^{-1} (5.83, 11.06 and 19.81 at 15, 30 and 45 DAT) was found from the control treatment M_0 (Fig. 4). The extended retention of moisture and availability of moisture also leading to higher uptake of nutrient for proper growth and development of plants, resulted in maximum number of leaves, as compared to control. Similar result was also observed in okra by Jha and Neupane (2018) and Santos *et al*. (2003).

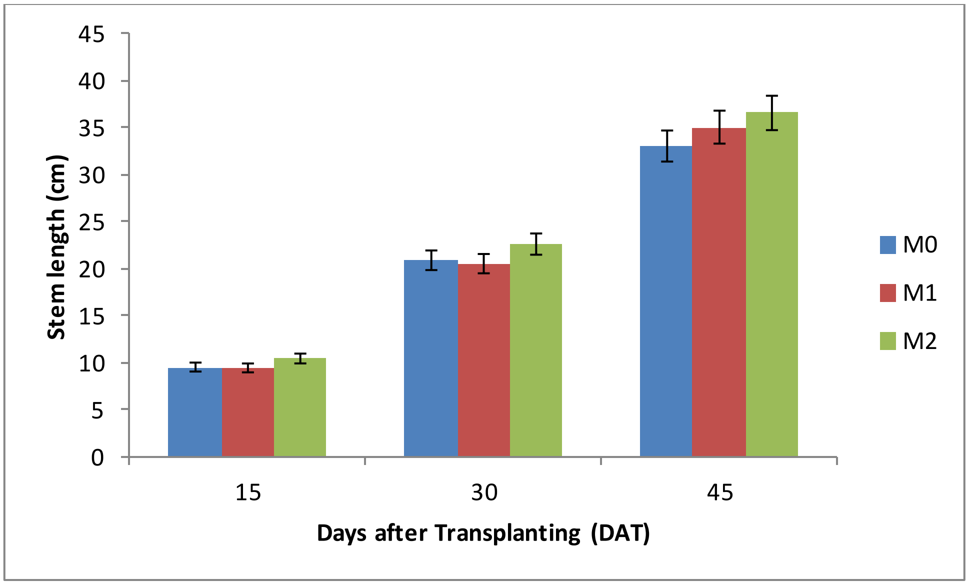


Fig. 2. Effect of mulching on stem length of squash

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

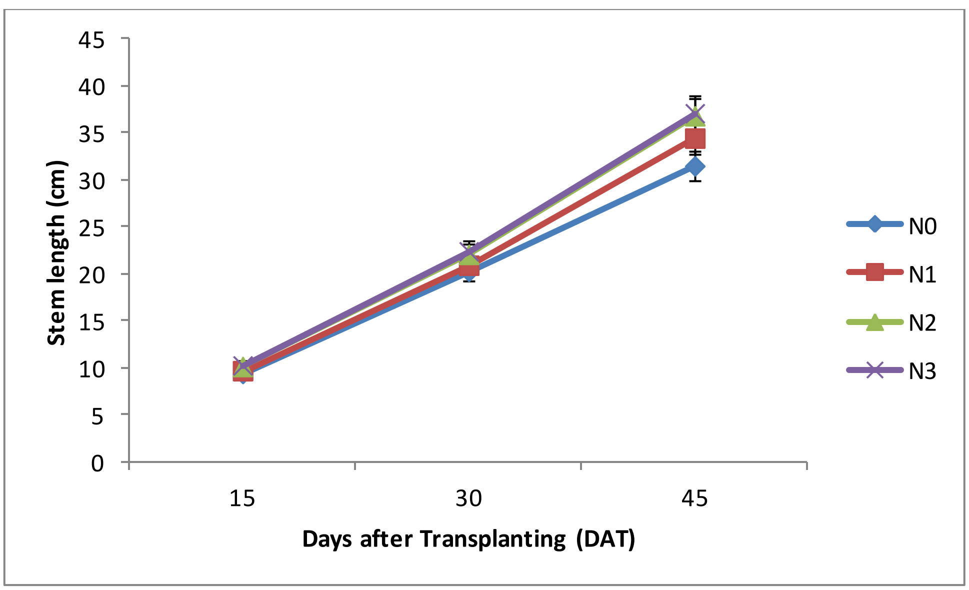


Fig. 3. Effect of nitrogen on stem length of squash

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Table 1. Combined effect of mulching and nitrogen on stem length of squash

Treatment	Stem length (cm)		
	15 DAT	30 DAT	45 DAT
M_0N_0	9.00 h	19.89 g	30.00 f
M_0N_1	9.45 fg	20.00 fg	33.44 d
M_0N_2	9.67 ef	21.44 c	33.50 d
M_0N_3	10.00 cd	22.22 b	35.22 bc
M_1N_0	9.11 h	19.56 h	32.05 e
M_1N_1	9.22 gh	20.22 f	35.39 bc
M_1N_2	9.67 ef	21.00 e	36.55 b
M_1N_3	9.78 de	21.33 cd	36.22 b
M_2N_0	9.89 de	21.11 de	32.17 e
M_2N_1	10.22 bc	22.33 b	34.28 cd
M_2N_2	10.45 b	22.45 b	39.61 a
M_2N_3	11.22 a	24.56 a	40.17 a
$LSD_{0.05}$	0.285	0.301	1.273
CV(%)	7.85	9.48	9.09

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Significant variation was observed on number of leaves plant^{-1} at different growth stages influenced by different nitrogen levels (Appendix V). The highest number of leaves plant^{-1} (6.74, 12.74 and 22.30 at 15, 30 and 45 DAT) was found from the N treatment of N_3 (180 kg N ha^{-1}) which was statistically identical with N_1 (80 kg N ha^{-1}) and N_2 (130 kg N ha^{-1}). The lowest number of leaves plant^{-1} (5.63, 10.85 and 19.33 at 15, 30 and 45 DAT) was found from the control treatment N_0 (Fig. 5). Nitrogen plays a vital role in photosynthesis. So, optimum nitrogen level might have led to higher photosynthetic activity through production of more number of leaves plant^{-1}. The result obtained from the present study was similar with the findings of Ngetich *et al*. (2013) who stated that the number of leaves in zucchini plant was higher at nitrogen 160 kg ha^{-1} as compared to control (0 kg N ha^{-1}). The result was conformity with the result found by Mohamed *et al*. (2010) in case of squash.

There was a significant variation on number of leaves plant^{-1} at different growth stages influenced by combined effect of mulching and nitrogen (Appendix V). The highest number of leaves plant^{-1} (7.22, 14.11 and 24.67 cm at 15, 30 and 45 DAT) was found from the treatment combination of M_2N_3 which was statistically similar with M_2N_2 at 15 DAT but significantly different from all other treatment combinations at 30 and 45 DAT. The lowest number of leaves plant^{-1} (5.33, 10.56 and 18.89 at 15, 30 and 45 DAT) was found from the treatment combination of M_0N_0 which was statistically similar with the treatment combination of M_0N_1 at 30 and 45 DAT (Table 2).

4.1.3 Leaf length

There was a significant variation on leaf length influenced by different mulching treatment at different growth stages (Appendix VII). The highest leaf length (13.31, 23.69 and 28.83 cm at 15, 30 and 45 DAT) was found from the mulching treatment, M_2 (Black polythene) which was significantly different from other treatments followed by M_1 (Straw mulch). The lowest leaf length (11.83, 20.47 and 25.89cm at 15, 30 and 45 DAT) was found from the Control treatment M_0 (Fig. 6). Similar result was also observed by Jha and Neupane (2018) in okra.

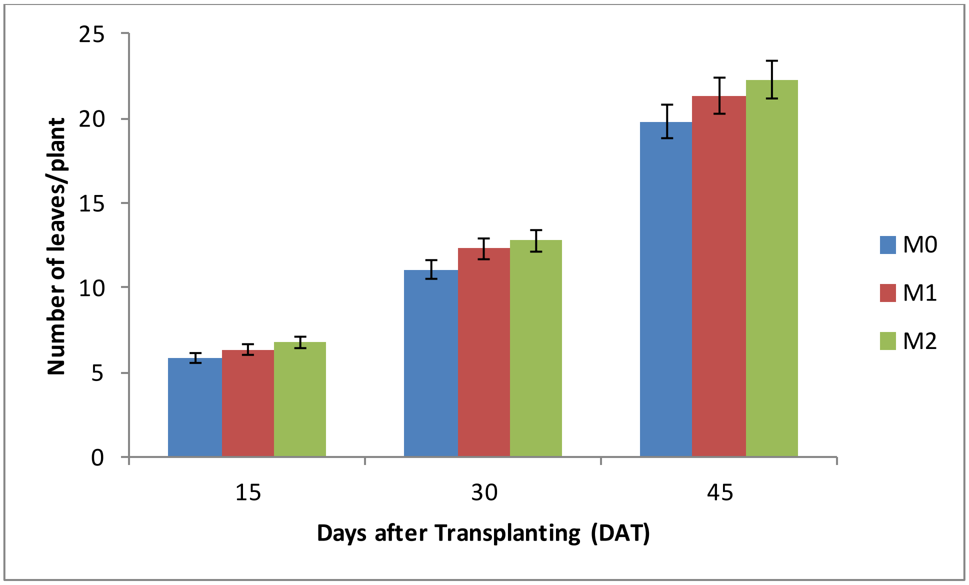


Fig. 4. Effect of mulching on number of leaves plant^{-1} of squash

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

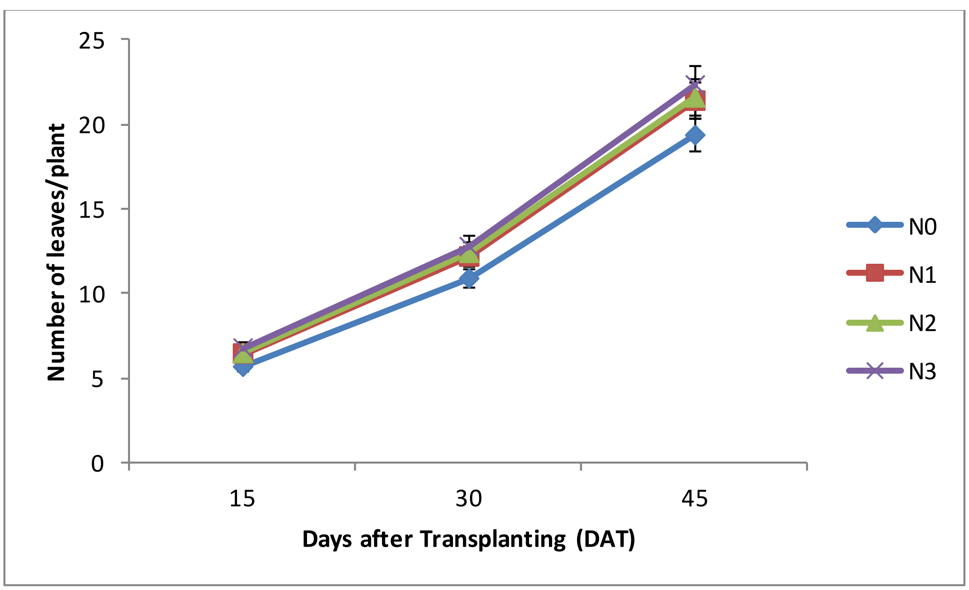


Fig. 5. Effect nitrogen on number of leaves plant^{-1} of squash

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Table 2. Combined effect of mulching and nitrogen on number of leaves plant^{-1} of squash

Treatment	Number of leaves plant^{-1}		
	15 DAT	30 DAT	45 DAT
M_0N_0	5.33 g	10.56 f	18.89 g
M_0N_1	6.78 bc	11.00 ef	19.11 fg
M_0N_2	6.55 c	12.78 cd	20.56 e
M_0N_3	6.66 c	12.33 d	20.66 e
M_1N_0	5.44 g	11.00 ef	19.56 f
M_1N_1	6.22 d	10.67 f	23.11 b
M_1N_2	5.78 f	11.33 e	21.44 d
M_1N_3	5.89 ef	11.22 e	21.22 d
M_2N_0	6.11 de	13.44 b	19.55 f
M_2N_1	6.67 c	12.89 c	22.22 c
M_2N_2	7.00 ab	13.00 bc	22.67 bc
M_2N_3	7.22 a	14.11 a	24.67 a
$LSD_{0.05}$	0.262	0.473	0.522
CV(%)	11.67	8.50	10.23

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

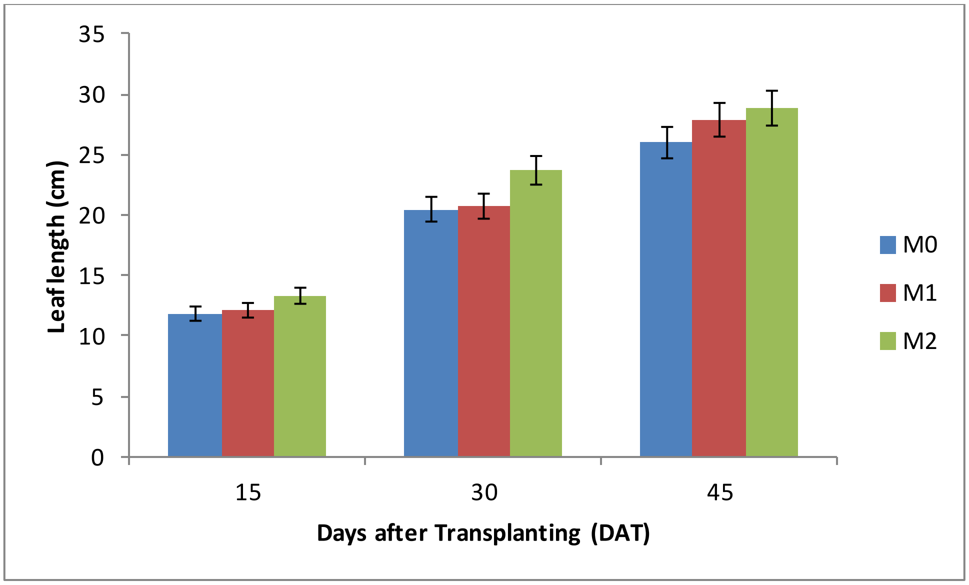


Fig. 6. Effect of mulching on leaf length of squash

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

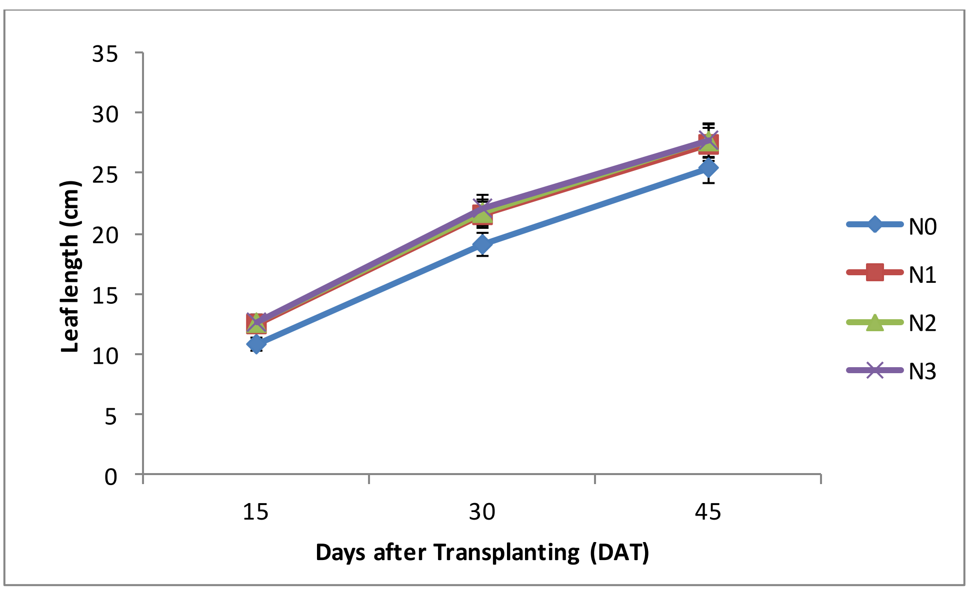


Fig. 7. Effect of mulching on leaf length of squash

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Table 3. Combined effect of mulching and nitrogen on leaf length of squash

Treatment	Leaf length (cm)		
	15 DAT	30 DAT	45 DAT
M_0N_0	10.55 g	19.45 g	24.06 g
M_0N_1	12.67 cd	22.44 c	26.94 de
M_0N_2	12.56 de	19.78 fg	26.22 ef
M_0N_3	12.67 cd	21.22 d	28.50 c
M_1N_0	11.33 f	19.11 g	24.44 g
M_1N_1	12.33 de	20.44 ef	28.61 c
M_1N_2	13.11 b	20.89 de	27.28 d
M_1N_3	12.22 e	21.45 d	29.39 b
M_2N_0	11.44 f	22.45 c	25.83 f
M_2N_1	13.00 bc	23.45 b	28.50 c
M_2N_2	13.52 a	24.33 a	29.72 b
M_2N_3	13.56 a	24.55 a	31.28 a
$LSD_{0.05}$	0.332	0.693	0.776
CV(%)	10.80	9.21	10.18

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha

Leaf length was significantly influenced by different nitrogen levels at different growth stages (Appendix VI). The highest leaf length (12.67, 22.11 and 27.74 cm at 15, 30 and 45 DAT) was found from the N treatment of N_3 (180 kg N ha^{-1}) which was statistically identical with N_2 (130 kg N ha^{-1}) at 15 and 45 DAT. The lowest leaf length (10.85, 19.11 and 25.46 cm at 15, 30 and 45 DAT) was found from the control treatment N_0 (Fig. 7). Nitrogen is part of the chlorophyll molecule, which gives plants their green color and is involved in creating food for the plant through photosynthesis. So, optimum nitrogen level might have led to higher photosynthetic activity through production of larger leaves. The result obtained from the present study was similar with the findings of Mohamed *et al*. (2010).

Leaf length of squash at different growth stages was significantly influenced by combined effect of mulching and nitrogen (Appendix VI). The highest leaf length (13.56, 24.55, 31.28 cm at 15, 30 and 45 DAT) was found from the treatment combination of M_2N_3 which was statistically identical with M_2N_2 at 15 and 30 DAT. The lowest leaf length (10.55, 19.45 and 24.06 cm at 15, 30 and 45 DAT) was found from the treatment combination of M_0N_o (Table 3) which was statistically identical with the treatment combination of M_1N_0 at 30 and 45 DAT.

4.1.4 Leaf breadth

Leaf breadth was significantly influenced by different mulching treatment at different growth stages (Appendix VII). The highest leaf breadth (14.72, 22.72 and 24.71 cm at 15, 30 and 45 DAT) was found from the mulching treatment, M_2 (Black polythene) which was statistically identical with M_1 (Straw mulch) at 45 DAT. The lowest leaf breadth (12.69, 19.90 and 23.61 cm at 15, 30 and 45 DAT) was found from the control treatment M_0 (Fig. 8).

There was a significant variation on leaf breadth influenced by different nitrogen levels at different growth stages (Appendix VII). The highest leaf breadth (14.33, 21.92 and 24.96 cm at 15, 30 and 45 DAT) was found from the N treatment of

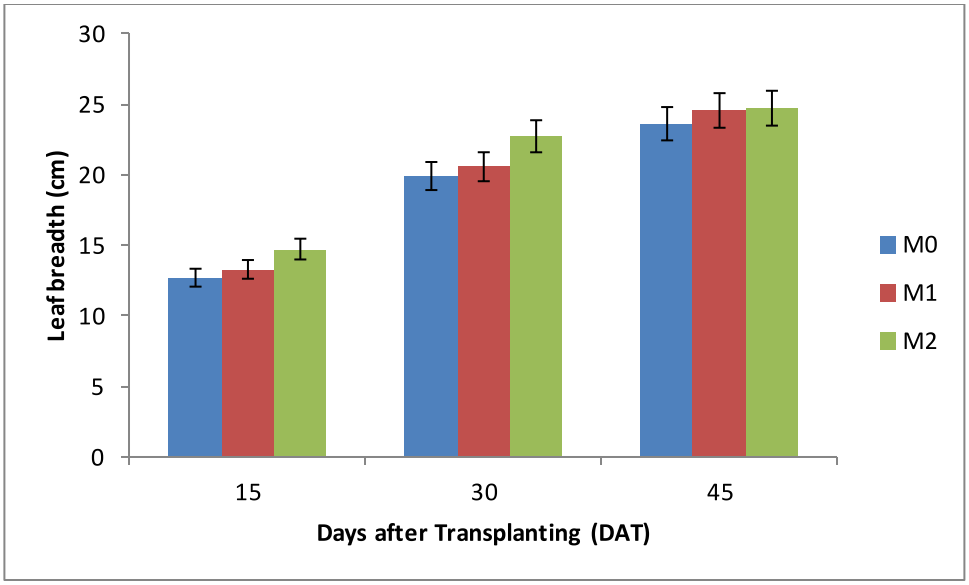


Fig. 8. Effect of mulching on leaf breadth of squash plant

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

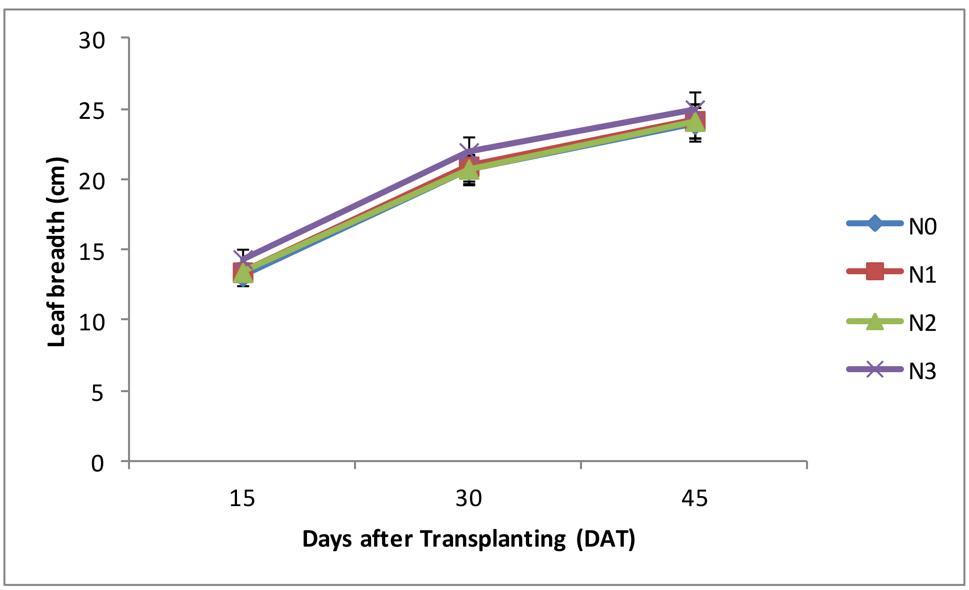


Fig. 9. Effect of nitrogen on leaf breadth of squash plant

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Table 4. Combined effect of mulching and nitrogen on leaf breadth of squash plant

Treatment	Leaf breadth (cm)		
	15 DAT	30 DAT	45 DAT
M_0N_0	11.78 f	19.55 e	20.94 e
M_0N_1	13.56 c	20.11 de	24.83 c
M_0N_2	12.45 e	20.22 de	25.05 c
M_0N_3	13.44 c	20.07 de	25.56 bc
M_1N_0	13.34 cd	19.89 e	20.44 e
M_1N_1	13.67 c	20.67 d	25.95 b
M_1N_2	12.78 de	21.55 c	24.94 c
M_1N_3	13.66 c	19.78 e	22.27 d
M_2N_0	12.56 e	21.67 c	25.33 bc
M_2N_1	14.89 b	22.00 c	22.11 d
M_2N_2	15.00 b	22.89 b	27.06 a
M_2N_3	15.67 a	24.33 a	27.00 a
$LSD_{0.05}$	0.596	0.631	0.742
CV(%)	9.84	9.55	10.84

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

N_3 (180 kg N ha^{-1}) which was significantly different from other treatments. The lowest leaf breadth (13.11, 20.65 and 23.91 cm at 15, 30 and 45 DAT) was found from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_1 (80 kg N ha^{-1}) and N_2 (130 kg N ha^{-1}) at 45 DAT (Fig. 9).

Significant variation was observed on leaf breadth at different growth stages influenced by combined effect of mulching and nitrogen (Appendix VII). The highest leaf breadth (15.67, 24.33 and 27.00 cm at 15, 30 and 45 DAT) was found from the treatment combination of M_2N_3 which was statistically identical with the treatment combination of M_2N_2 at 45 DAT (Table 4). The lowest leaf breadth (11.78, 19.55 and 20.94 cm at 15, 30 and 45 DAT) was found from the treatment combination of M_0N_0 which was statistically identical with M_1N_0 at 30 and 45 DAT.

4.1.5 Stem base diameter

Significant variation was observed on stem base diameter at different growth stages influenced by different mulching treatment except at 15 DAT (Appendix VIII). The highest stem base diameter (0.96, 1.14 and 2.30 cm at 15, 30 and 45 DAT) was found from the mulching treatment, M_2 (Black polythene). The lowest stem base diameter (0.94, 1.00 and 2.13 cm at 15, 30 and 45 DAT) was found from the control treatment M_0 (No mulch) which was statistically identical with M_1 (Straw mulch) at 45 DAT (Fig. 10). As plastic mulching could save irrigation water and reduce evapo-transpiration in most cases, soil health improved and thus plant growth parameter like average stem base diameter was found higher in black polythene mulched plot than the non-mulched plot. Bhatt *et al*. (2011) found the similar result during studying with squash.

Stem base diameter was significantly varied due to different nitrogen levels at all growth stages except at 15 DAT (Appendix VIII). The highest stem base diameter (1.00, 1.21 and 2.33 cm at 15, 30 and 45 DAT) was found from the N treatment of N_3 (180 kg N ha^{-1}) which was statistically identical with N_2 (130 kg N ha^{-1}) at 45 DAT.

The lowest stem base diameter (0.89, 0.91 and 2.02 cm at 15, 30 and 45 DAT) was found from the control treatment N_0 (0 kg N ha^{-1}) which was statistically identical with N_1 (80 kg N ha^{-1}) at 30 and 40 DAT (Fig. 11). Nitrogen being a major food for plants is an essential constituent of protein (build from amino acids that involves in catalization of chemical responses and transportation of electrons) and chlorophyll (enable the process of photosynthesis) present in many major portions of the plant body, plants treated with optimum level of nitrogen acquire vigorous vegetative growth compared to nitrogen untreated soil. Similar result was also observed by Ngetich *et al*. (2013) in summer squash.

Stem base diameter was significantly varied at different growth stages due to combined effect of mulching and nitrogen (Appendix VIII). The highest stem base diameter (1.02, 1.50 and 2.53 cm at 15, 30 and 45 DAT) was found from the treatment combination of M_2N_3 which was statistically identical with M_2N_2 at 45 DAT. The lowest stem base diameter (0.87, 0.90 and 1.97 cm at 15, 30 and 45 DAT) was found from the treatment combination of M_0N_0 which was statistically identical with the treatment combination of M_1N_0 at 30 DAT and statistically similar with the treatment combination of M_1N_0 at 45 DAT (Table 5).

4.2 Yield contributing parameters

4.2.1 Days to first flowering

Significant variation was not identified on days to first flowering due to the effect of different mulching treatment (Appendix IX). However, the highest days to first flowering (9.33) was found from the control treatment M_0 (No mulch) and the lowest days to first flowering (8.52) was found from the treatment M_2 (Black polythene). (Table 6). Higher soil moisture content and soil temperature under plastic mulch improve the plant microclimate leading to early growth and development, which advances the flowering.

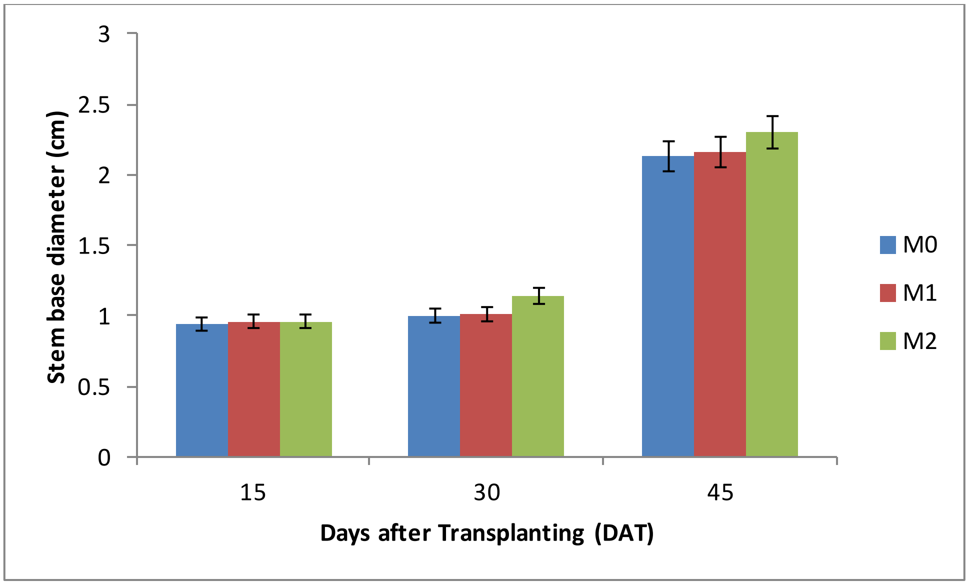


Fig. 10. Effect of mulching on stem base diameter of squash plant

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

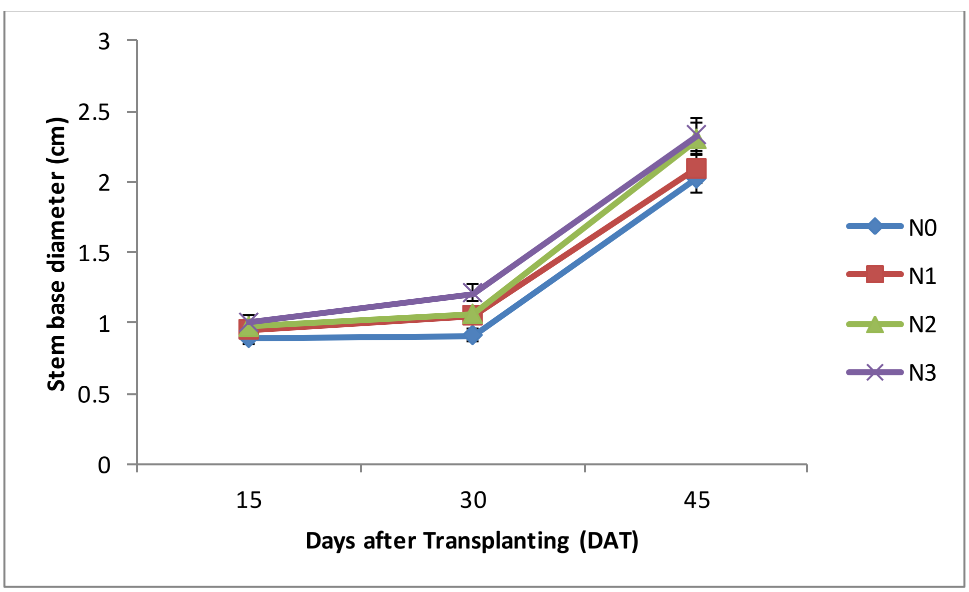


Fig. 11. Effect of nitrogen on stem base diameter of squash plant

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Table 5. Combined effect of mulching and nitrogen on stem base diameter of squash plant

Treatment	Stem base diameter (cm)		
	15 DAT	30 DAT	45 DAT
M_0N_0	0.87 h	0.90 e	1.97 f
M_0N_1	0.99 b	1.10 b	2.03 d-f
M_0N_2	0.97 cd	1.02 cd	2.23 c
M_0N_3	0.95 d	1.03 b-d	2.37 b
M_1N_0	0.89 g	0.92 e	2.00 ef
M_1N_1	0.93 e	1.01 bc	2.13 d
M_1N_2	0.93 e	1.02 cd	2.27 c
M_1N_3	0.99 b	1.10 b	2.13 d
M_2N_0	0.91 f	0.92 e	2.10 de
M_2N_1	0.98 bc	1.03 b-d	2.10 de
M_2N_2	0.99 b	1.11 b	2.50 a
M_2N_3	1.02 a	1.50 a	2.53 a
$LSD_{0.05}$	0.022	0.061	0.092
CV(%)	7.62	8.07	7.55

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Variation in days to first flowering was not significantly influenced by different nitrogen levels (Appendix IX). However, the highest days to first flowering (9.11) was found from the N treatment of N_3 (180 kg N ha^{-1}) and the lowest days to first flowering (8.78) was found from the treatment N_2 (Table 6).

The variation at recorded data on days to first flowering was significant with the combined effect of mulching and nitrogen (Appendix IX). The highest days to first flowering (10.00) was found from the treatment combination of M_0N_3 which was significantly different from all other treatment combinations followed by M_0N_2. The lowest days to first flowering (8.33) was found from the treatment combination of M_2N_2 which was statistically identical with the treatment combination of M_0N_1 and M_1N_2 (Table 7).

4.2.2 Number of female flower

Considerable influence was observed on number of female flower persuaded by different mulching treatment (Appendix IX). The highest number of female flower (4.71) was found from the mulching treatment, M_2 (Black polythene) followed by M_1 (Straw mulch). The lowest number of female flower (4.32) was found from the control treatment M_0 (Table 6).

Significant influence was noted on number of female flower affected by different nitrogen levels (Appendix IX). The highest number of female flower (5.50) was found from the N treatment of N_2 (130 kg N ha^{-1}) followed by N_1 (80 kg N ha^{-1}). The lowest number of female flower (3.44) was found from the control treatment N_0 (0 kg N ha^{-1}) followed by N_3 (Table 6). The result obtained from the present study was similar with the findings of Ngetich *et al*. (2013) in case of zucchini.

Number of female flower of squash affected by combined effect of mulching and nitrogen was significant (Appendix IX). The highest number of female flower (6.00) was found from the treatment combination of M_2N_2 which was significantly different from all other treatment combinations followed by M_1N_2. The lowest number of

Table 6. Effect of mulching and nitrogen on yield contributing parameters of days to first flowering, number of female flower and number of male flower

Treatment	Yield contributing parameters		
	Days to first flowering	No. of female flower	Number of male flower
Effect of mulching			
M_0	9.33	4.32 c	6.12 a
M_1	8.92	4.54 b	5.32 b
M_2	8.58	4.71 a	5.08 c
$LSD_{0.05}$	0.413	0.110	0.162
CV(%)	5.48	6.06	4.00
Effect of nitrogen			
N_0	8.89	3.44 d	4.26 c
N_1	9.00	4.81 b	5.44 b
N_2	8.78	5.50 a	6.11 a
N_3	9.11	4.33 c	6.22 a
$LSD_{0.05}$	0.331	0.157	0.213
CV(%)	5.48	6.06	4.00

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Table 7. Combined effect of mulching and nitrogen on yield contributing parameters of days to first flowering, number of female flower and number of male flower

Treatment	Yield contributing parameters		
	Days to first flowering	No. of female flower	Number of male flower
M_0N_0	9.00 c	3.33 g	3.67 e
M_0N_1	9.00 c	4.33 e	5.00 d
M_0N_2	9.33 b	5.00 cd	5.33 cd
M_0N_3	10.00 a	5.33 bc	7.33 a
M_1N_0	8.67 d	3.50 g	5.50 c
M_1N_1	9.33 b	4.77 d	6.33 b
M_1N_2	9.00 c	5.50 b	7.00 a
M_1N_3	8.67 d	3.67 fg	5.67 c
M_2N_0	8.67 d	3.50 g	3.60 e
M_2N_1	8.67 d	5.33 bc	5.00 d
M_2N_2	8.33 e	6.00 a	6.34 b
M_2N_3	8.67 d	4.00 ef	5.33 cd
$LSD_{0.05}$	0.263	0.357	0.391
CV(%)	5.48	6.06	4.00

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

female flower (3.33) was found from the treatment combination of M_0N_0 which was statistically identical with the treatment combination of M_1N_0 and M_2N_0 (Table 7).

4.2.3 Number of male flower

The recorded data on number of male flower was significant with the application of different mulching treatment (Appendix IX). The highest number of male flower (6.12) was found from the control treatment M_0 (No mulch) followed by M_1 (Straw mulch). The lowest number of male flower (5.08) was found from the mulching treatment M_2 (Table 6).

Significant variation on number of male flower was remarked as influenced by different nitrogen levels (Appendix IX). The highest number of male flower (6.22) was found from the N treatment of N_3 (180 kg N ha^{-1}) which was statistically identical with N_2 (130 kg N ha^{-1}). The lowest number of male flower (4.26) was found from the control treatment N_0 (Table 6). The result obtained from the present study was similar with the findings of Ngetich *et al*. (2013) in zucchini plant.

Variation on number of male flower was noted influenced by combined effect of mulching and nitrogen (Appendix IX). The highest number of male flower (7.33) was found from the treatment combination of M_0N_3 which was statistically identical with M_1N_2. The lowest number of male flower (3.67) was found from the treatment combination of M_0N_0 followed by M_0N_1 and M_2N_1 (Table 7).

4.2.4 Percent (%) leaf dry matter

Percent (%) leaf dry matter of squash was not affected by different mulching treatment was significant (Appendix X). However, the highest percent (%) leaf dry matter (11.18%) was found from the mulching treatment, M_2 (Black polythene) and the lowest percent (%) leaf dry matter (10.27%) was found from the control treatment M_0 (Table 8). Similar result was also observed by Zhang *et al*. (2009) in swiss chard and Crusciol *et al*. (2005) in turnip.

Percent (%) leaf dry matter was found significant with the application of different nitrogen levels (Appendix X). The highest percent (%) leaf dry matter (13.08%) was found from the N treatment of N_2 (130 kg N ha^{-1}) where the lowest percent (%) leaf dry matter (8.11%) was found from the control treatment N_0 (Table 8). The result obtained from the present study was similar with the findings of Mohamed *et al.* (2010) and Naderi *et al.* (2017).

Percent (%) leaf dry matter was found significant with the combined effect of mulching and nitrogen (Appendix X). The highest percent (%) leaf dry matter (13.83%) was found from the treatment combination of M_2N_2 which was significantly different from all other treatment combinations followed by M_0N_2, M_0N_3 and M_2N_1. The lowest percent (%) leaf dry matter (7.37%) was found from the treatment combination of M_0N_0 which was also significantly different from all other treatment combinations (Table 9).

4.2.5 Percent (%) fruit dry matter

Variation on percent (%) fruit dry matter was not found influenced by different mulching treatment (Appendix X). However, the highest percent (%) fruit dry matter (6.60%) was found from the mulching treatment, M_2 (Black polythene) and the lowest percent (%) fruit dry matter (6.07%) was found from the control treatment M_0 (Table 8). Similar result was also observed by Zhang *et al.* (2009), Crusciol *et al.* (2005) and Kumar *et al.* (2009).

Variation on percent (%) fruit dry matter was significantly influenced by different nitrogen levels (Appendix X). The highest percent (%) fruit dry matter (7.11%) was found from the N treatment of N_2 (130 kg N ha^{-1}) and the lowest percent (%) fruit dry matter (5.41%) was found from the control treatment N_0 (Table 8). Similar result was also observed by Mohamed *et al.* (2010) and Naderi *et al.* (2017).

Significant variation was remarked on percent (%) fruit dry matter as influenced by combined effect of mulching and nitrogen (Appendix X). The highest percent (%) fruit dry matter (7.34%) was found from the treatment combination of M_2N_2 which was statistically identical with M_0N_2, M_1N_2 and M_2N_1 (Table 9). The lowest percent (%) fruit dry matter (4.61%) was found from the treatment combination of M_0N_0 which was significantly different from all other treatment combinations.

4.2.6 Fruit length

Fruit length was not significant with the application of different mulching treatment (Appendix X). However, the highest fruit length (25.67 cm) was found from the mulching treatment, M_2 (Black polythene) and the lowest fruit length (24.72 cm) was found from the control treatment M_0 (Table 8).

The recorded data on fruit length was significant with the application of different nitrogen levels (Appendix X). The highest fruit length (27.06 cm) was found from the N treatment of N_2 (130 kg N ha^{-1}) followed by N_1 (80 kg N ha^{-1}) and N_3 (180 kg N ha^{-1}). The lowest fruit length (22.61 cm) was found from the control treatment N_0 (Table 8). Similar result was also observed by Mohamed *et al*. (2010) and Ngetich *et al*. (2013).

Fruit length varied significantly due to combined effect of mulching and nitrogen (Appendix X). The highest fruit length (28.03 cm) was found from the treatment combination of M_2N_2 which was significantly different from all other treatment combinations followed by the treatment combination of M_1N_1. The lowest fruit length (21.42%) was found from the treatment combination of M_0N_0 which was also significantly different from all other treatment combinations followed by the treatment combination of M_1N_0 (Table 9).

4.2.7 Fruit diameter

Significant variation was not found on fruit diameter as influenced by different mulching treatment (Appendix XI). However, the highest fruit diameter (5.65 cm) was found from the mulching treatment, M_2 (Black polythene) and the lowest fruit

Table 8. Effect of mulching and nitrogen on yield contributing parameters of % leaf dry matter, % fruit dry matter and fruit length

Treatment	Yield contributing parameters		
	% leaf dry matter	% fruit dry matter	Fruit length (cm)
Effect of mulching			
M_0	10.27	6.07	24.72
M_1	10.52	6.34	24.99
M_2	11.18	6.60	25.67
$LSD_{0.05}$	0.28	0.21	0.39
CV(%)	3.82	4.00	7.14
Effect of nitrogen			
N_0	8.11 d	5.41 c	22.61 c
N_1	11.06 b	6.59 b	25.65 b
N_2	13.08 a	7.11 a	27.06 a
N_3	10.38 c	6.23 b	25.19 b
$LSD_{0.05}$	0.550	0.504	0.461
CV(%)	4.00	7.14	8.10

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Table 9. Combined Effect of mulching and nitrogen on yield contributing parameters of % leaf dry matter, % fruit dry matter and fruit length

Treatment	Yield contributing parameters		
	% leaf dry matter	% fruit dry matter	Fruit length (cm)
M_0N_0	7.37 g	4.61 d	21.42 h
M_0N_1	9.88 d	6.34 b	25.54 cd
M_0N_2	12.48 b	6.89 a	26.00 c
M_0N_3	12.33 b	6.44 b	25.93 c
M_1N_0	8.24 f	5.77 c	22.82 g
M_1N_1	10.67 c	6.43 b	25.32 d
M_1N_2	12.92 b	7.10 a	27.16 b
M_1N_3	9.27 de	6.04 bc	24.67 e
M_2N_0	8.72 ef	5.86 c	23.58 f
M_2N_1	12.64 b	6.99 a	26.09 c
M_2N_2	13.83 a	7.34 a	28.03 a
M_2N_3	9.53 d	6.21 bc	24.98 de
$LSD_{0.05}$	0.693	0.431	0.570
CV(%)	4.00	7.14	8.10

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

diameter (5.43 cm) was found from the control treatment M_0 (Table 10).

Significant variation was observed on fruit diameter persuaded by different nitrogen levels (Appendix XI). The highest fruit diameter (6.00 cm) was found from the N treatment of N_2 (130 kg N ha^{-1}) followed by N_1 (80 kg N ha^{-1}) and N_3 (180 kg N ha^{-1}). The lowest fruit diameter (5.02 cm) was found from the control treatment N_0 (Table 10). The result obtained from the present study was similar with the findings of Mohamed *et al*. (2010) and Ngetich *et al*. (2013).

Significant influence was noted on fruit diameter affected by combined effect of mulching and nitrogen (Appendix XI). The highest fruit diameter (6.13 cm) was found from the treatment combination of M_2N_2 which was statistically identical with the treatment combination of M_1N_2. The lowest fruit diameter (4.80 cm) was found from the treatment combination of M_0N_0 which was significantly different from all other treatment combinations followed by the treatment combination of M_1N_0 (Table 11).

4.2.8 Number of fruits plant^{-1}

Significant influence was noted on number of fruits plant^{-1} affected by different mulching treatment (Appendix XI). The highest number of fruits plant^{-1} (4.31) was found from the mulching treatment, M_2 (Black polythene). The lowest number of fruits plant^{-1} (3.89) was found from the control treatment M_0 (No mulch) which was statistically identical with M_1 (Table 10). The results indicated that plants under black polythene mulch produced highest number of fruit per plant because of the better plant growth that due to favorable hydro-thermal regime of soil and complete weed free environment.

Significant variation was remarked on number of fruits plant^{-1} as influenced by different nitrogen levels (Appendix XI). The highest number of fruits plant^{-1} (5.30) was found from the nitrogen treatment of N_2 (130 kg N ha^{-1}) followed by N_1 (80 kg N ha^{-1}). The lowest number of fruits per plant (2.67) was found from the control treatment N_0 (Table 10) followed by N_3 (180 kg N ha^{-1}). The result obtained from the present study was similar with the findings of Mohamed *et al*. (2010) in summer squash.

Number of fruits plant^{-1} was significantly influenced by combined effect of mulching and nitrogen (Appendix XI). The highest number of fruits plant^{-1} (5.56) was found from the treatment combination of M_2N_2 which was statistically identical with the treatment combination of M_1N_2. The lowest number of fruits plant^{-1} (2.33) was found from the treatment combination of M_0N_0 followed by the treatment combination of M_1N_0 (Table 11).

4.2.9 Individual fruit weight

Significant variation was observed on individual fruit weight influenced by different mulching treatment (Appendix XI). The highest individual fruit weight (456.80 g) was found from the mulching treatment, M_2 (Black polythene) followed by M_1 (Straw mulch). The lowest individual fruit weight (425.20 g) was found from the control treatment M_0 (Table 10). Similar result was also observed by Akhter *et al*. (2018) who concluded that the individual fruit weight of squash increased with mulching application. Mulching retains soil moisture that helps to increase fruit weight of squash.

Variation on individual fruit weight was significantly influenced by different nitrogen levels (Appendix XII). The highest individual fruit weight (512.54 g) was found from the N treatment of N_2 (130 kg N ha^{-1}) followed by N_1 (80 kg N ha^{-1}). The lowest individual fruit weight (345.66 g) was found from the control treatment N_0 (0 kg N ha^{-1}) followed by N_3 (Table 10). The result obtained from the present study was consistent with the findings of Mohamed *et al*. (2010) in summer squash.

The recorded data on individual fruit weight was significant with the combined effect of mulching and nitrogen (Appendix XI). The highest individual fruit weight (522.00 g) was found from the treatment combination of M_2N_2 which was significantly different from all other treatment combinations followed by the treatment combination

Table 10. Effect of mulching and nitrogen on yield contributing parameters of fruit diameter number of fruits plant^{-1} and single fruit weight

Treatment	Yield contributing parameters		
	Fruit diameter (cm)	**No. of fruits plant^{-1}**	**Single fruit weight (g)**
Effect of mulching			
M_0	5.43	3.89 b	425.20 c
M_1	5.51	3.94 b	430.80 b
M_2	5.65	4.31 a	456.80 a
$LSD_{0.05}$	0.380	0.194	3.291
CV(%)	8.10	9.09	9.88
Effect of nitrogen			
N_0	5.02 c	2.67 d	345.66 d
N_1	5.62 b	4.41 b	461.45 b
N_2	6.00 a	5.30 a	512.54 a
N_3	5.49 b	3.81 c	430.69 c
$LSD_{0.05}$	0.158	0.160	7.113
CV(%)	9.09	9.88	4.00

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Table 11. Combined Effect of mulching and nitrogen on yield contributing parameters of fruit diameter, number of fruits plant^{-1} and single fruit weight

Treatment	Yield contributing parameters		
	Fruit diameter (cm)	No. of fruits plant^{-1}	Single fruit weight (g)
M_0N_0	4.80 g	2.33 h	292.70 k
M_0N_1	5.50 cd	3.67 e	435.80 f
M_0N_2	5.74 b	4.89 bc	508.30 b
M_0N_3	5.66 bc	4.67 cd	464.10 d
M_1N_0	5.04 f	2.66 g	354.90 j
M_1N_1	5.53 cd	4.56 d	451.10 e
M_1N_2	6.12 a	5.45 a	507.30 b
M_1N_3	5.36 de	3.11 f	409.80 h
M_2N_0	5.20 ef	3.00 f	389.40 i
M_2N_1	5.84 b	5.00 b	497.50 c
M_2N_2	6.13 a	5.56 a	522.00 a
M_2N_3	5.44 d	3.67 e	418.10 g
$LSD_{0.05}$	0.183	0.266	6.790
CV(%)	9.09	9.88	4.00

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Of M_1N_2. The lowest individual fruit weight (292.70 g) was found from the treatment combination M_0N_0 followed by the treatment combination of M_1N_0 (Table 11).

4.3 Yield parameters

4.3.1 Fruit yield plot^{-1}

Significant variation was identified on fruit yield plot^{-1} due to the effect of different mulching treatment (Appendix XII). The highest fruit yield plot^{-1} (8.08 kg) was found from the mulching treatment, M_2 (Black polythene). The lowest fruit yield plot^{-1} (6.85 kg) was found from the control treatment M_0 (No mulch) which was statistically identical with M_1 (Table 12). The results indicated that mulching plant produced maximum yield due to conserve moisture and increase temperature. Similar result was found by Khalak and Kumaraswamy (1992) that mulching with straw and polythene gave average higher tuber yields compared to without mulching.

The recorded data on fruit yield plot^{-1} was significant with the application of different nitrogen levels (Appendix XII). The highest fruit yield plot^{-1} (10.72 kg) was found from the N treatment of N_2 (130 kg N ha^{-1}) followed by N_1 (80 kg N ha^{-1}). The lowest fruit yield plot^{-1} (3.75 kg) was found from the control treatment N_0 (0 kg N ha^{-1}) followed by N_3 (Table 12). The results indicated that maximum yield was attained by the N_2 treatment among the different levels of nitrogen. Ngetich *et al*. (2013) found similar result in case of zucchini.

Fruit yield plot^{-1} of squash affected by combined effect of mulching and nitrogen was significant (Appendix XII). The highest fruit yield plot^{-1} (11.59 kg) was found from the treatment combination of M_2N_2 which was statistically identical with the treatment combination of M_1N_2. The lowest fruit yield plot^{-1} (2.72 kg) was found from the treatment combination of M_0N_0 which was significantly different from all other treatment combinations followed by the treatment combination of M_1N_0 (Table 13).

4.3.2 Fruit yield ha^{-1}

Significant variation was identified on fruit yield ha^{-1} due to the effect of different

Table 12. Effect of mulching and nitrogen on yield parameters of squash plant

Treatment	Yield parameters	
	Fruit yield $plot^{-1}$ (kg)	Fruit yield ha^{-1} (t)
Effect of mulching		
M_0	6.85 b	16.87 c
M_1	7.05 b	17.62 b
M_2	8.08 a	20.20 a
$LSD_{0.05}$	0.502	0.580
CV(%)	9.39	7.85
Effect of nitrogen		
N_0	3.75 d	9.37 d
N_1	8.21 b	20.20 b
N_2	10.72 a	26.79 a
N_3	6.62 c	16.55 c
$LSD_{0.05}$	1.532	1.921
CV(%)	9.39	7.85

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Table 13. Combined effect of mulching and nitrogen on yield parameters of squash plant

Treatment	Yield parameters	
	Fruit yield plot^{-1} (kg)	Fruit yield ha^{-1} (t)
M_0N_0	2.72 g	6.81 h
M_0N_1	6.45 d	15.15 e
M_0N_2	9.54 b	23.85 bc
M_0N_3	8.67 c	21.67 cd
M_1N_0	3.85 f	9.61 g
M_1N_1	8.22 c	20.56 d
M_1N_2	11.04 a	27.08 a
M_1N_3	5.09 e	12.72 f
M_2N_0	4.68 ef	11.69 fg
M_2N_1	9.95 b	24.89 b
M_2N_2	11.59 a	28.95 a
M_2N_3	6.11 d	15.26 e
$LSD_{0.05}$	0.867	2.310
CV(%)	9.39	7.85

In a column means having similar letter (s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

mulching treatments (Appendix XII). The highest fruit yield ha^{-1} (20.20 t ha^{-1}) was found from the mulching treatment, M_2 (Black polythene) followed by M_1 (Straw mulch). The lowest fruit yield ha^{-1} (16.87 t ha^{-1}) was found from the control treatment M_0 (Table 12). The result obtained from the present study was conformity with the findings of Akhter *et al*. (2018), Soleymani *et al*. (2015) and Crusciol *et al*. (2005).

Significant variation was observed on fruit yield ha^{-1} affected by different nitrogen levels (Appendix XII). The highest fruit yield ha^{-1} (26.79 t ha^{-1}) was found from the N treatment of N_2 (130 kg N ha^{-1}) which was significantly different from other treatments followed by N_1 (80 kg N ha^{-1}). The lowest fruit yield ha^{-1} (9.37 t ha^{-1}) was found from the control treatment N_0 (0 kg N ha^{-1}) followed by N_3 (Table 12). The result obtained from the present study was similar with the findings of Naderi *et al*. (2017) and Mohamed *et al*. (2010).

Variation on fruit yield ha^{-1} was noted as significantly influenced by combined effect of mulching and nitrogen (Appendix XII). The highest fruit yield ha^{-1} (28.95 t ha^{-1}) was found from the treatment combination of M_2N_2 which was statistically identical with the treatment combination of M_1N_2. The lowest fruit yield ha^{-1} (6.81 t ha^{-1}) was found from the treatment combination of M_0N_0 which was significantly different from all other treatment combinations followed by the treatment combination of M_1N_0 (Table 13).

4.4 Economic analysis

All the material and non-material input cost like land preparation, squash seed cost, manure and fertilizer cost, irrigation and manpower required for all the operation, interest on fixed capital of land (Leased land by bank loan basis) and miscellaneous cost were considered for calculating the total cost of production from planting seed to harvesting of squash were recorded for unit plot and converted into cost per hectare (Table 14 and Appendix XIII). Price of squash was considered at market rate @ Tk. 15 kg^{-1}.

The economic analysis is presented under the following headlines:

4.4.1 Gross income

The combination of different mulching and nitrogen levels showed different gross return (Table 14). Gross income was calculated on the basis of market price of squash fruit. The highest gross return (Tk 434250) was obtained from M_2N_2 (Black polythene with 130 kg N ha^{-1}) treatment combination and lowest gross return (Tk 102150) obtained from the treatment combination of M_0N_0 (No mulch with 0 kg N ha^{-1}).

4.4.2 Net return

Treatment combinations of different mulching and nitrogen levels showed net returns variation (Table 14). The highest net return (Tk 305430) was obtained from the treatment combination of M_2N_2 (Black polythene with 130 kg N ha^{-1}) and lowest net return (Tk 108) obtained from the treatment combination of M_0N_0 (No mulch with 0 kg N ha^{-1}).

4.4.3 Benefit cost ratio (BCR)

Among different treatment combinations of mulching and nitrogen levels, variation on BCR was observed among the treatment combinations (Table 14). The Benefit cost ratio (BCR) was highest (3.37) from the treatment combination of M_2N_2 (Black polythene with 130 kg N ha^{-1}) and lowest BCR (1.00) was obtained from M_0N_0 (No mulch with 0 kg N ha^{-1}) treatment combination. The treatment combinations of M_1N_2 and M_0N_1 also showed promising results on BCR which were nearest to the BCR value of M_2N_2. From economic point of view, it was noticeable from the above results, the treatment combination of M_2N_2 (Black polythene with 130 kg N ha^{-1}) was more profitable than rest of the treatment combinations.

Table 14. Economic analysis of squash production as influenced by mulching and nitrogen application

Treatment	Economic analysis				
	Yield (t ha^{-1})	Total cost of production (Tk. ha^{-1})	Gross return (Tk. ha^{-1})	Net return (Tk. ha^{-1})	BCR
M_0N_0	6.81	102042	102150	108	1.00
M_0N_1	15.15	105081	227250	122169	2.16
M_0N_2	23.85	106980	357750	250770	3.34
M_0N_3	21.67	108879	325050	216171	2.99
M_1N_0	9.613	116238	144195	27957	1.24
M_1N_1	20.56	119277	308400	189123	2.59
M_1N_2	27.08	121176	406200	285024	3.35
M_1N_3	12.72	123075	190800	67725	1.55
M_2N_0	11.69	123882	175350	51468	1.42
M_2N_1	24.89	126921	373350	246429	2.94
M_2N_2	28.95	128820	434250	305430	3.37
M_2N_3	15.26	130719	228900	98181	1.75

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 to find out the effect of different mulch materials and nitrogen on growth and yield of squash during the period from November 2017 to February 2018. The seed of First Runner F_1 Hybrid Squash was used as planting materials. The experiment consisted of two factors: Factor A: three mulching practices as M_0: No mulch (Control), M_1: Straw mulch and M_2: Black polythene and Factor B: four levels of nitrogen application as N_0: 0 kg N ha^{-1} (Control), N_1: 80 kg N ha^{-1}, N_2: 130 kg N ha^{-1}, N_3: 180 kg N ha^{-1}. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield contributing parameters and yield parameters were recorded and statistically analyzed using MSTAT-C computer package program. Different mulching treatments and nitrogen doses and also their combinations showed significant influence of different growth, yield contributing parameters and yield of squash.

In terms of mulching effect, all the studied parameters were significantly varied except days to first flowering, % leaf dry matter, % fruit dry matter, fruit length and fruit diameter. Considering growth parameters, the highest stem length (10.44, 22.61 and 36.56 cm at 15, 30 and 45 DAT), number of leaves $plant^{-1}$ (6.75, 12.75 and 22.28 at 15, 30 and 45 DAT), leaf length (13.31, 23.69 and 28.83 cm at 15, 30 and 45 DAT), leaf breadth (14.72, 22.72 and 24.71 cm at 15, 30 and 45 DAT) and stem base diameter (0.96, 1.11 and 2.30 cm at 15, 30 and 45 DAT) were found from the mulching treatment, M_2 (Black polythene) where the lowest stem length (9.53, 20.89 and 33.04 cm at 15, 30 and 45 DAT), number of leaves $plant^{-1}$ (5.83, 11.06 and 19.81 at 15, 30 and 45 DAT), leaf length (11.83, 20.47 and 25.89cm at 15, 30 and 45 DAT), leaf breadth (12.69, 19.90 and 23.61 cm at 15, 30 and 45 DAT) and stem base diameter (0.94, 0.96 and 2.13 cm at 15, 30 and 45 DAT) were found from the control treatment M_0 (No mulch). Considering yield contributing parameters and yield of squash, the highest percent (%) leaf dry matter (11.18%), number of female flower (4.71), percent (%) fruit dry matter (6.60%), fruit length (25.67 cm), fruit diameter (5.65 cm), number of fruits plant^{-1} (4.31), single fruit weight (456.80 g), fruit yield plot^{-1} (8.08 kg) and fruit yield ha^{-1} (20.20 t ha^{-1}) were found from the mulching treatment, M_2 (Black polythene). The lowest number of male flower (5.08) was also found from the treatment M_2 (Black polythene). Similarly, the lowest days to first flowering (8.52), number of female flower (4.32), percent (%) leaf dry matter (10.27%), percent (%) fruit dry matter (6.07%), fruit length (24.72 cm), fruit diameter (5.43 cm), number of fruits plant^{-1} (3.89), single fruit weight (425.20 g), fruit yield plot^{-1} (6.85 kg) and fruit yield ha^{-1} (16.87 t ha^{-1}) were found from the control treatment M_0 (No mulch). But the highest days to first flowering (9.33) and number of male flower (6.12) was also found from the control treatment M_0 (No mulch). Different nitrogen treatments also showed significant influence on different growth, yield and yield contributing parameters except days to first flowering.

In terms of nitrogen (N) effect, regarding growth parameters, the highest stem length (10.19, 22.33 and 37.02 cm at 15, 30 and 45 DAT), number of leaves plant^{-1} (6.74, 12.74 and 22.30 at 15, 30 and 45 DAT), leaf length (12.67, 22.11 and 27.74 cm at 15, 30 and 45 DAT), leaf breadth (14.33, 21.92 and 24.96 cm at 15, 30 and 45 DAT) and stem base diameter (1.00, 1.21 and 2.33 cm at 15, 30 and 45 DAT) were found from the N treatment of N_3 (180 kg N ha^{-1}). But the lowest stem length (9.33, 20.19 and 31.41 cm at 15, 30 and 45 DAT), number of leaves plant^{-1} (5.63, 10.85 and 19.33 at 15, 30 and 45 DAT), leaf length (10.85, 19.11 and 25.46 cm at 15, 30 and 45 DAT), leaf breadth (13.11, 20.65 and 23.91 cm at 15, 30 and 45 DAT) and stem base diameter (0.89, 0.88 and 2.02 cm at 15, 30 and 45 DAT) were found from the control treatment N_0 (0 kg N ha^{-1}). Considering yield and yield contributing parameters, the highest number of female flower (5.50), percent (%) leaf dry matter (13.08%), percent (%) fruit dry matter (7.11%), fruit length (27.06 cm), fruit diameter (6.00 cm), number of fruits plant^{-1} (5.30), single fruit weight (512.54 g), fruit yield plot^{-1} (10.72 kg) and fruit yield ha^{-1} (26.79 t ha^{-1}) were found from the N treatment of N_2 (130 kg N ha^{-1}). The lowest days to first flowering (8.78) was also found from the treatment N_2 (130 kg N ha^{-1}) but the highest days to first flowering (9.11) and number of male flower (6.22) was found from the N treatment of N_3 (180 kg N ha^{-1}). Similarly, the lowest number of female flower (3.44), number of male flower (4.26), percent (%) leaf dry matter (8.11%), percent (%) fruit dry matter (5.41%), fruit length (22.61 cm), fruit diameter (5.02 cm), number of fruits plant^{-1} (2.67), single fruit weight (345.66 g), fruit yield plot^{-1} (3.75 kg) and fruit yield ha^{-1} (9.37 t ha^{-1}) were found from the control treatment N_0 (0 kg N ha^{-1}).

Different treatment combinations of mulching and nitrogen was also showed significant influence on different growth, yield and yield contributing parameters. Regarding growth parameters, the highest stem length (11.22, 24.56 and 40.17 cm at 15, 30 and 45 DAT), number of leaves plant^{-1} (7.22, 14.11 and 24.67 cm at 15, 30 and 45 DAT), leaf length (13.56, 24.55, 31.28 cm at 15, 30 and 45 DAT), leaf breadth (15.67, 24.33 and 27.00 cm at 15, 30 and 45 DAT) and stem base diameter (1.02, 1.50 and 2.53 cm at 15, 30 and 45 DAT) were found from the treatment combination of M_2N_3 whereas the lowest stem length (9.00, 19.89 and 30.00 cm at 15, 30 and 45 DAT), number of leaves plant^{-1} (5.33, 10.56 and 18.89 at 15, 30 and 45 DAT), leaf length (10.55, 19.45 and 24.06 cm at 15, 30 and 45 DAT), leaf breadth (11.78, 19.55 and 20.94 cm at 15, 30 and 45 DAT) and stem base diameter (0.87, 0.81 and 1.97 cm at 15, 30 and 45 DAT) were found from the treatment combination of M_0N_0. Considering yield and yield contributing parameters, the highest number of female flower (6.00), percent (%) leaf dry matter (13.83%), percent (%) fruit dry matter (7.34%), fruit length (28.03 cm), fruit diameter (6.13 cm), number of fruits plant^{-1} (5.56), single fruit weight (522.00 g), fruit yield plot^{-1} (11.59 kg) and fruit yield ha^{-1}

(28.95 t ha^{-1}) was found from the treatment combination of M_2N_2. The lowest days to first flowering (8.33) was also found from the treatment combination of M_2N_2. But the lowest number of male flower (3.67), number of female flower (3.33), percent (%) leaf dry matter (7.37%), percent (%) fruit dry matter (4.61%), fruit length (21.42 cm), fruit diameter (4.80 cm), number of fruits $plant^{-1}$ (2.33), single fruit weight (292.70 g), fruit yield $plot^{-1}$ (2.72 kg) and fruit yield ha^{-1} (6.81 t ha^{-1}) were found from the treatment combination of M_0N_0. Likewise the highest days to first flowering (10.00) and highest number of male flower (7.33) were found from the treatment combination of M_0N_3. In case of economic point of view, the highest gross return (Tk 434250), net return (Tk 305430) and BCR (3.37) were obtained from the treatment combination of M_2N_2 (Black polythene with 130 kg N ha^{-1}) where the lowest gross return (Tk 102150), net return (Tk 108) and BCR (1.00) was obtained from treatment combination M_0N_0 (No mulch with 0 kg N ha^{-1})

Conclusion

Considering the findings of the present study, the following conclusions might be drawn:

- Use of black polythene mulch showed best vegetative growth and yield of squash by means of improving soil health;
- Nitrogen (180 kg ha^{-1}) showed best results for vegetative growth and nitrogen (130 kg ha^{-1}) gave best results for yield of squash;
- Black polythene mulch in combination with nitrogen (130 kg ha^{-1}) is suitable for squash cultivation in terms of economic return.

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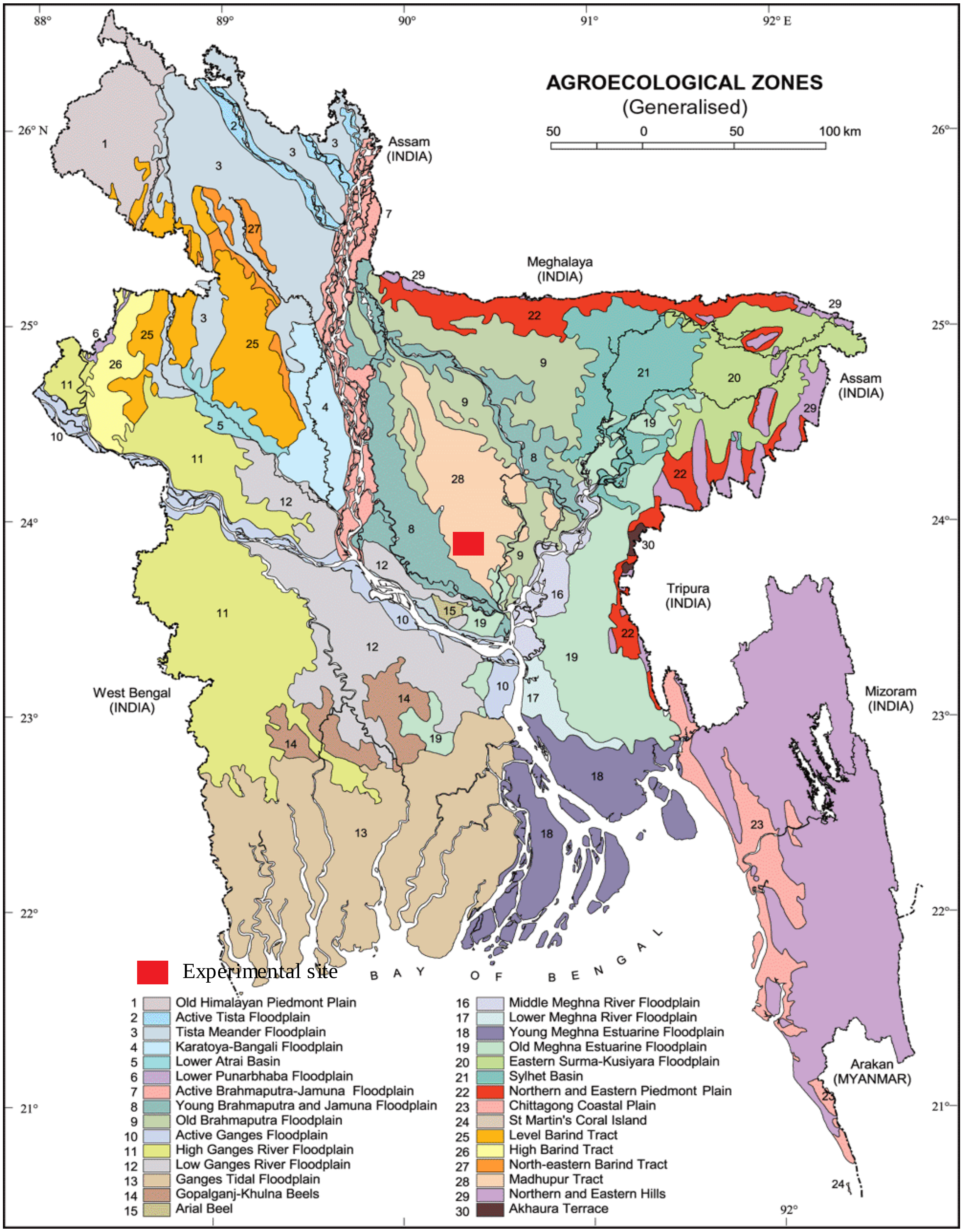
APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location



Appendix II. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix III. Monthly records of air temperature, relative humidity and rainfall during the period from November 2017 to February 2018.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	Min	Mean		
2017	November	28.60	8.52	18.56	56.75	14.40
2017	December	25.50	6.70	16.10	54.80	0.0
2018	January	23.80	11.70	17.75	46.20	0.0
2018	February	22.75	14.26	18.51	37.90	0.0

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix IV. Analysis of variance of data on stem length of squash

Source	Degrees of freedom	Mean square of stem length (cm)		
		15 DAT	30 DAT	45 DAT
Replication	2	2.332	5.572	4.233
Factor A (Mulching)	2	3.698*	14.880*	37.294*
Factor B (Nitrogen)	3	1.414*	8.976*	61.031*
A×B	6	0.201**	1.470*	6.428*
Error	22	0.592	4.090	10.051

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

Appendix V. Analysis of variance of data on number of leaves plant^{-1} of squash

Source	Degrees of freedom	Mean square of number of leaves plant^{-1}		
		15 DAT	30 DAT	45 DAT
Replication	2	0.571	1.594	2.194
Factor A (Mulching)	2	2.537*	9.169*	18.694*
Factor B (Nitrogen)	3	2.028**	6.060*	14.475*
A×B	6	0.169**	1.888*	3.884*
Error	22	0.542	1.046	4.678

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

Appendix VI. Analysis of variance of data on leaf length of squash

Source	Degrees of freedom	Mean square of leaf length (cm)		
		15 DAT	30 DAT	45 DAT
Replication	2	0.009	1.915	8.213
Factor A (Mulching)	2	7.352*	38.563*	25.201*
Factor B (Nitrogen)	3	1.314*	1.548*	0.246*
A×B	6	1.497*	4.966*	17.435**
Error	22	1.799	3.966	15.260

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

Appendix VII. Analysis of variance of data on leaf breadth of squash plant

Source	Degrees of freedom	Mean square of leaf breadth (cm)		
		15 DAT	30 DAT	45 DAT
Replication	2	1.226	3.816	4.363
Factor A (Mulching)	2	13.085*	26.129*	4.232*
Factor B (Nitrogen)	3	2.527*	3.103**	1.919**
A×B	6	1.569*	1.536*	25.903*
Error	22	1.781	4.048	30.797

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

Appendix VIII. Analysis of variance of data on stem base diameter of squash plant

Source	Degrees of freedom	Mean square of stem base diameter (cm)		
		15 DAT	30 DAT	45 DAT
Replication	2	0.075	1.059	0.021
Factor A (Mulching)	2	0.002^{NS}	0.064*	0.104*
Factor B (Nitrogen)	3	0.020^{NS}	0.179*	0.238*
A×B	6	0.001**	0.068**	0.028**
Error	22	0.012	0.035	0.148

Here,** = Significant at 1% level and * =Significant at 5% level, ^{NS} = Non-significant

Appendix IX. Analysis of variance of data on days to first flowering, number of female flower and number of male flower

Source	Degrees of freedom	Mean square of yield contributing parameters		
		Days to first flowering	No. of female flower	Number of male flower
Replication	2	1.028	2.340	3.358
Factor A (Mulching)	2	1.694^{NS}	0.460**	3.575*
Factor B (Nitrogen)	3	0.185^{NS}	6.711*	7.340*
A×B	6	0.435*	1.133*	2.413*
Error	22	0.240	0.011	0.049

Here,** = Significant at 1% level and * =Significant at 5% level, NS = Non-significant

Appendix X. Analysis of variance of data % leaf dry matter, % fruit dry matter and fruit length

Source	Degrees of freedom	Mean square of yield contributing parameters		
		% leaf dry matter	% fruit dry matter	Fruit length (cm)
Replication	2	0.437	0.271	0.031
Factor A (Mulching)	2	2.638^{NS}	2.014^{NS}	3.288^{NS}
Factor B (Nitrogen)	3	37.751*	4.573*	31.082*
A×B	6	4.962*	0.420**	1.867**
Error	22	0.008	0.064	3.221

Here,** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant

Appendix XI. Analysis of variance of data of fruit diameter, number of fruits plant^{-1} and single fruit weight

Source	Degrees of freedom	Mean square of yield contributing parameters		
		Fruit diameter (cm)	No. of fruits plant^{-1}	Single fruit weight (g)
Replication	2	0.329	0.395	37.378
Factor A (Mulching)	2	0.158^{NS}	0.615**	339.181*
Factor B (Nitrogen)	3	1.478**	10.974*	4405.082*
A×B	6	0.096**	1.117*	322.235*
Error	22	0.201	0.597	18.106

Here,** = Significant at 1% level and * = Significant at 5% level, NS = Non-significant

Appendix XII. Analysis of variance of data on yield contributing parameters of squash plant

Source	Degrees of freedom	Mean square of yield parameters	
		Fruit yield plot^{-1} (kg)	Fruit yield ha^{-1} (t)
Replication	2	3.418	2.045
Factor A (Mulching)	2	5.254*	36.545*
Factor B (Nitrogen)	3	76.833*	475.484*
A×B	6	6.796*	45.881*
Error	22	2.455	15.868

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

Appendix XIII: Cost of production of squash per hectare

A. Input cost (Tk ha^{-1})

Treatments	Cultivation with Labor	Seed cost	Pesticides	Irrigation	Mulching cost (price and labor)	Seed sowing/ trans-planting cost	Manure and fertilizer					Subtotal (A)
							Compost	Urea	TSP	MoP	Gypsum	
M_0N_0	12000	3000	3500	5000	0	16000	8000	0	4250	2400	1200	55350
M_0N_1	12000	3000	3500	5000	0	16000	8000	2783	4250	2400	1200	58133
M_0N_2	12000	3000	3500	5000	0	16000	8000	4522	4250	2400	1200	59872
M_0N_3	12000	3000	3500	5000	0	16000	8000	6261	4250	2400	1200	61611
M_1N_0	12000	3000	3500	5000	13000	16000	8000	0	4250	2400	1200	68350
M_1N_1	12000	3000	3500	5000	13000	16000	8000	2783	4250	2400	1200	71133
M_1N_2	12000	3000	3500	5000	13000	16000	8000	4522	4250	2400	1200	72872
M_1N_3	12000	3000	3500	5000	13000	16000	8000	6261	4250	2400	1200	74611
M_2N_0	12000	3000	3500	5000	20000	16000	8000	0	4250	2400	1200	75350
M_2N_1	12000	3000	3500	5000	20000	16000	8000	2783	4250	2400	1200	78133
M_2N_2	12000	3000	3500	5000	20000	16000	8000	4522	4250	2400	1200	79872
M_2N_3	12000	3000	3500	5000	20000	16000	8000	6261	4250	2400	1200	81611

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

B. Overhead cost (Tk. ha^{-1}), Cost of production (Tk. ha^{-1}), Gross return (Tk. ha^{-1}), Net return (Tk. ha-1) and BCR

Treatments	Overhead cost (Tk. ha^{-1})				Subtotal (A)	Total cost of production (A+B)	Yield ha^{-1} (ton)	Gross return (Tk. ha^{-1})**	Net return (Tk. ha^{-1})	BCR
	Cost of leased land for 6 months (8% of value of land Tk. 10,00,000/-	Miscellaneous cost (Tk. 5% of the input cost)	Interest on running capital for 6 month (8% of cost year^{-1})	Subtotal (B)						
M_0N_0	40000	2767.5	3925	46692.2	55350	102042	6.81	102150	108	1.00
M_0N_1	40000	2906.65	4042	46948.24	58133	105081	15.15	227250	122169	2.16
M_0N_2	40000	2993.6	4115	47108.22	59872	106980	23.85	357750	250770	3.34
M_0N_3	40000	3080.55	4188	47268.21	61611	108879	21.67	325050	216171	2.99
M_1N_0	40000	3417.5	4471	47888.2	68350	116238	9.613	144195	27957	1.24
M_1N_1	40000	3556.65	4588	48144.24	71133	119277	20.56	308400	189123	2.59
M_1N_2	40000	3643.6	4661	48304.22	72872	121176	27.08	406200	285024	3.35
M_1N_3	40000	3730.55	4734	48464.21	74611	123075	12.72	190800	67725	1.55
M_2N_0	40000	3767.5	4765	48532.2	75350	123882	11.69	175350	51468	1.42
M_2N_1	40000	3906.65	4882	48788.24	78133	126921	24.89	373350	246429	2.94
M_2N_2	40000	3993.6	4955	48948.22	79872	128820	28.95	434250	305430	3.37
M_2N_3	40000	4080.55	5028	49108.21	81611	130719	15.26	228900	98181	1.75

** Selling cost = 15.00 Tk kg^{-1}

M_0 = No mulch (Control), M_1 = Straw mulch, M_2 = Black polythene

N_0 = 0 kg N ha^{-1}, N_1 = 80 kg N ha^{-1}, N_2 = 130 kg N ha^{-1}, N_3 = 180 kg N ha^{-1}

Plate 1. Photograph showing experimental field

Plate 2. Photograph showing black polythene mulch in plot

Plate 3. Photograph showing straw mulch in plot

Plate 4. Photograph showing harvested fruits