INFLUENCE OF PLANT DENSITY AND FERTILIZATION ON THE GROWTH AND SEED YIELD OF BUNCHING ONION

ANAMIKA SARKAR

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

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BY

ANAMIKA SARKAR

REGISTRATION NO. 1910249

E-Mail Address: anamikasarker69@gmail.com
Mobile No: +880 1767020939

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Approved by:

(Prof. Dr. Khaleda Khatun)
Department of Horticulture
Supervisor

(Prof. Dr. Tahmina Mostarin)
Department of Horticulture
Co-supervisor

(Prof. Dr. Khaleda Khatun)
Chairman
Examination Committee

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

CERTIFICATE

This is to certify that the thesis entitled *"INFLUENCE OF PLANT DENSITY AND FERTILIZATION ON THE GROWTH AND SEED YIELD OF BUNCHING ONION"* ***submitted to*** *the,* ***Department*** *of Horticulture,* ***Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of*** *MASTER OF SCIENCE (MS)* ***in*** *Horticulture,* ***embodies the results of a piece of bona fide research work carried out by*** *Anamika Sarkar, Registration*. ***No.*** *1910249* ***under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.***

I further certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated: December,2021

Dhaka, Bangladesh

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

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INFLUENCE OF PLANT DENSITY AND FERTILIZATION ON THE GROWTH AND SEED YIELD OF BUNCHING ONION

ABSTRACT

A field experiment was conducted in the field of Sher-e- Bangla Agricultural University, Dhaka, Bangladesh during the period from November 2020 to April 2021. The experiment consisted of three levels of spacing (viz. S_1 = 20cm×10cm, S_2 = 20cm×15cm, S_3= 20cm×20cm) and four levels of fertilizer (viz. F_0 = No application (control), F_1= $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2 =$N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3= $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$). The two-factor experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. There were 12 treatment combinations in this study. A unit plot was 1.2 m×1.2 m and the treatments were distributed randomly in each block. Data on growth and yield parameters were recorded and analyzed statistically. Growth and yield of bunching onion were influenced by the different spacing. The 20cm×20cm spacing resulted in the highest number of leaves, dry matter content in leaves, umbel diameter, number of seeds per umbel, thousand seed weight and percent of gemination. The maximum seed yield per hectare (1065 kg) was observed in 20cm×10cm spacing. Different levels of fertilizer had also significant influence on yield of bunching onion. The highest plant height, number of leaves, length and diameter of flower stem, umbel diameter, seed yield per plot and per hectare (157.48 g/plot and 1056.3 kg/ha, respectively), number of flowers per umbel, number of seeds per umbel, thousand seed weight and percent of gemination were found from the $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$ treatment. The highest seed yield (1260 kg/ha) with net income (Tk.699991.4) and BCR (2.26) were observed from S_1F_3 treatment combination, while the lowest were from S_3F_0 treatment combination. So, economic analysis revealed that the S_1F_3 treatment combination appeared to the best for achieving the higher yield and economic benefit of bunching onion.

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LIST OF ACRONYMS

BARI	= Bangladesh Agricultural Research Institute
BAU	= Bangladesh Agricultural University
BBS	= Bangladesh Bureau of Statistics
CV%	= Percentage of coefficient of variance
DAE	= Department of Agricultural Extension
DAT	= Days after Transplanting
et al.	= And others
FAO	= Food and Agriculture Organization
g	= Gram
ha^{-1}	= Per Hectare
Kg	= Kilogram
LSD	= Least Significant Difference
Max	= Maximum
Min	= Minimum
mg	= milligram
MoP	= Muriate of Potash
N	= Nitrogen
No.	= Number
NS	= Not significant
SAU	= Sher-e-Bangla Agricultural University
SRDI	= Soil Resources and Development Institute
TSP	= Triple Super Phosphate
wt.	= Weight
%	= Percent
^0C	= Degree Celsius

CHAPTER I

INTRODUCTION

The perennial onion known as the bunching onion (*Allium fistulosum* L.) is a member of Amaryllidaceae family (Fritsch and Friesen,2002). It is probably originated in China. It reached Japan before 500 AD. One of the most significant crops in eastern Asia, particularly in China, Japan, and Korea (Inden and Asahira,1990). Commercially, it is grown as an annual or a biennial, and is typically seed propagated. Tender green onions (*Allium fistulosum* L.) may be called scallions, welsh onions, green onions, spring onions, salad onions, Negi, Japanese bunching onions and the list goes on. The growth of bunching onions is quick in the spring and autumn and slows down in the summer and winter (Mansour, 1990). In any type of well-drained soil that is rich in organic matter, bunch onions can be grown very easily (Maryati and Isnaini, 2011). According to Martinez *et al.* (2005), *Allium fistulosum* L. is resistant to a number of bulb onion diseases and pests, including pink root rot. It is a new crop in Bangladesh, and because of its flavor and taste, it can be used as a substitute to onions. Almost all of the *A. fistulosum* plant's components, including the shoots, leaves, and undeveloped bulbs, are consumed raw in salads, cooked as vegetables, or used as medicinal herbs.

According to the USDA (2002), the nutritional breakdown of 100 g of raw green tops is as follows: Water 90.5 g, energy 142 kj, protein 1.9 g, fat 0.4 g, carbohydrate 6.5 g, Ca 18mg, Mg 23 mg, P 49 mg, Fe 1.2 mg, Zn 0.52 mg, vitamin A 1160 IU, thiamin 0.05 mg, riboflavin 0.09 mg, niacin 0.40 mg. Welsh onion leaves have significant concentrations of quercetin, a flavonol molecule that may have positive benefits on human health, including lowering the risk of cardiovascular disease, acting as an anticancer agent due to its antiprostanoid and anti-inflammatory responses, and slowing DNA deterioration (Crystal *et al*., 2003; Feng and Liu 2011).

Japanese bunch onions are grown because of their strong tolerance to cold temperatures, minimal need for soil nutrients, excellent nutritional value, and distinctive flavor (Yamasaki *et al*., 2003; Su *et al*., 2007). (Laziae *et al.*, 2002, Stainer *et al*., 2006, Tendaj and Mysiak 2008).

Japanese bunch onion is rich in vitamin C, according to Kotlinska and Kojima (2000) and Higashio *et al*. (2007), but it also contains other beneficial substances including carotenoids, macro- and micronutrients, particularly Ca and K, as well as flavonoids, which are strong antioxidants (Mysiak and Tendaj, 2008). Typically, leaf blades contain more minerals, vitamins, and carotenoids than the pseudo stem does (Warade and Shinde, 1998). Additionally, it aids in the healing of wounds and infected sores as well as common colds, headaches, heart conditions, and poor eyesight.

One of the key elements that primarily affects the yields, quality, and frequently the ripeness of a certain cultivar is the planting spacing. Through adequate use of moisture, light, spacing, and nutrients, proper spacing ensures optimum plant growth (Zubeldia and Gases, 1977). Due to competition for growth factors among nearby plants, the yield per unit area decreases as plant yields continue to diminish with increasing plant density.

Fertilizer management is one of the important factors that contribute in the production and yield of bunching onion. The most crucial nutrients for vegetative growth of the crop are nitrogen, phosphorus, potassium, and sulfur. For vegetative growth and a target value, a sufficient amount of nitrogen is necessary (Yoshizawa and Roan. 1981). Due to its impact on plant height, leaf number per plant, bulb weight, and yield per plant, nitrogen is a very significant ingredient (Vachhani and Patel, 1993). Plants utilize nitrogen to produce a lot of new leaves and a dark green color. Thus, it is crucial for the cultivation of bunching onions. All plants require phosphorus to maintain their general well-being and vigor. It aids in promoting the growth of roots, boosting stalk and stem strength, enhancing flower formation and seed production, promoting more uniform and earlier crop maturity, enhancing crop quality, and boosting plant disease resistance. As with other tuber and root crops, bunching onions have shallow roots and love potash. They also respond well to potash. Increased crop resistance to numerous diseases, stalk and stem breaking, and under stressful conditions is a result of adequate potassium levels (Razzaque *et al.* 2000). The plant height, leaf number per plant maximum, leaf fresh weight, leaf dry weight, bulb diameter, fresh weight, and bulb yield were all highest at the highest potassium rate. Sulphur is also thought to be crucial for the growth of bunching onions. It has been noted that the majority of Bangladesh's soils are sulfur deficient (Dc Datta, 1981). An effective dressing of sulfur fertilizer boosted trace element availability while enhancing growth, yield, and pungent flavor (Misra and Prasad, 1966).

Vermicompost is a nutritious "organic fertilizer" that is "rich in micronutrients, helpful soil bacteria, and plant development hormones and enzymes". It is also known as a plant promoter and protector. Vermicompost is a fantastic, nutrient-rich organic fertilizer and soil conditioner since it includes water-soluble compounds (Coyne, Kelly, and Erik,2008). This substance is a source of nutrients that plants can utilize for a long time since it is both easier to dissolve and slow to release (Buchanan *et al*.1988). It expands macropores, which improves the soil's air-water connection and benefits plant growth (Marinari *et al.*, 2000).

Feces from poultry animals are utilized as an organic fertilizer, particularly for soils with low nitrogen levels (Mishra and Bangar, 1986). Poultry manures are particularly high in nitrogen and phosphorus when composted (Moral *et al*. 2009). Due to the high levels of protein and amino acids present, poultry manure contains significant concentrations of organic nitrogen. It has the highest concentration of N, P, and K of any animal manures (Singh and Amberger,1991).

Bunching onion is the most important special vegetable crop in Bangladesh. We are importing major share of bunching onion seeds from foreign countries. The price of seeds are increasing day by day and our farmers are depending on the big companies. It is important to stop import seeds by producing locally and locally produced will be more adaptive to the local climate. Low seed yield of bunching onion in our country can mainly be attributed to the non-availability of good quality seeds, because very little research work on seed production of bunching onion has been done in Bangladesh although the climate and soil of Bangladesh is suitable for the production of bunching onion seeds. This research will help the farmers to produce quality seeds of bunching onion which will increase production as well as will help to ensure income benefit of the farmers.

In this aspect, the present investigation was under taken with the following objectives:

1.To ascertain the ideal plant spacing for bunching onion in order to achieve the maximum growth and seed production.

2.To identify suitable combination of NPKS fertilizer, vermicompost and poultry manure for maximum growth and seed yield of bunching onion.

3.To determine the combined effect of fertilizer combination and plant spacing for maximum growth and seed yield of bunching onion.

4.To evaluate the cost and return in seed yield of bunching onion.

CHAPTER II

REVIEW OF LITERATURE

Around the world, bunched onions are a significant crop. However, it is not widely known in Bangladesh. Numerous elements, including spacing and fertilizer application, have an impact on the production of bunching onions seed. The goal of the current study is to determine how plant density and fertilizer affect the growth and seed yield of bunching onions. This chapter has a review of literature includes reports on bunching onion and other related crops studied by several previous research that is currently available.

2.1 Effects of spacing on growth and yield of bunching onion

To investigate the impact of levels of spacing and varieties on onion growth, Kumar *et al.* (2021) conducted research at the Horticulture Research Farm-2, Department of Horticulture, School of Agricultural Science and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow (Uttar Pradesh) from November 2018 to April 2019. (*Allium cepa* L.) A RCBD with three replications and 9 different treatment combinations was set up with three different spacings [S_1:15cm×10cm, S_2:15cm×15cm, and S_3:15cm×20cm] and three different types [NHRDF-2(V_1), Agri found Dark Red (V_2), and Agri found Light Red (V_3)]. According to the study, the greatest application was when Agri found Dark Red (V_2) variety was used with 15cm×15cm (S_2) spacing. The study also demonstrated that S_2V_2 treatment for wider spacing produced the highest plant height, leaf number, and neck diameter.

Amare *et al.* (2020) conducted an experiment in Shewa Robit, Northern Ethiopia to examine the effects of plant spacing and NP fertilizer levels on onion (*Allium cepa* L.) growth, seed yield, and quality. Plant spacing of 10cm×20cm×40cm, 20cm×30cm×50cm, 10cm×40cm,10cm×50cm,10cm×30cm and NP fertilizer levels of 86.25 P_2O_5 and 85.5 N kg/ha, 115 P_2O_5 and 114 N kg/ha, 143.6 P_2O_5 and 142.5 N kg/ha, 69 P_2O_5 and 142 N kg/ha, and control were the components of the treatments in a 5×5 factorial arrangement of RCBD with three replications. The fertilizer with 115 P_2O_5 and 114 N kg/ha produced the maximum seed production per ha (879.4 kg) and per plot (663.6 g). The interaction impact of 10cm×30cm, 143.6 P_2O_5, and 142.5 N kg/ha resulted in the best germination percentage. For high yield and high-quality onion seed production in Ethiopia, plant spacing of 10cm×30cm followed by 20cm×30cm×50cm and 115 P_2O_5 and 114 N kg/ha fertilizers was recommended.

Kumar *et al.* (2018) evaluated the effects of spacing (15cm ×10cm, 15cm×15cm, and 10cm ×10cm) and various nitrogenous fertilizers (urea, calcium nitrate, and N:P: K mixture) on the growth, yield, and quality of onions. The N:P: K application with 10 cm intra and inter row spacing produced the tallest plants (63.67 cm). With the application of calcium nitrate at a spacing of 15cm ×10 cm, the maximum plant height (30, 60, and 90 DAT) and leaf count (60, 90, and 120 DAT) were noted. T_1S_2 (18.53 T/ha) had the highest overall bulb production.

Ginoya (2018) was conducted at the Sagdividi Farm, Department of Seed Science and Technology College of Agriculture, Junagadh Agricultural University, Junagadh during rabi 2016-17 with an aim to examine the effect of bulb size [B_1 (25 ± 5 g, small size), B_2 (50 ± 5 g, medium size) and B_3 (75 ± 5 g, large size)] and plant spacing [S_1 (30 cm × 30 cm), S_2 (30 cm × 40 cm), S_3 (45 cm × 30 cm), S_4 (45 cm × 40 cm), S_5 (60 cm × 30 cm) and S_6 (60 cm × 40 cm)] on seed yield and economics of onion seed production cv. Gujarat Junagadh White Onion 3 (GJWO 3). Significantly the highest seed yield per plant of 8.05 g and 7.55 g was obtained in the plants raised from the largest bulb size 75 ± 5 g (B_3) and at the spacing of 60 cm × 40 cm (S_6), respectively. Seed yield per hectare recorded significantly high in largest bulb size (288.78 kg ha^{-1}) and in medium spacing of 45 cm × 30 cm (S_3) (435.09 kg ha^{-1}). The treatment combination $B_3 \times S_3$ (bulb size 75 ± 5 g planted at the spacing of 45 cm × 30 cm) produced the maximum seed yield per hectare (526.71 kg/ha). The highest gross return (421368 /ha) was obtained from the seed harvested from bulb size (75 ± 5 g) planted at a spacing of 45 cm × 30 cm ($B_3 \times S_3$) and it was followed by ($B_3 \times S_1$) treatment combination (bulb size 75 ± 5 g and spacing (30 cm × 30 cm) with gross return 418496 ha^{-1}.The seed extracted from bulb size (75±5 g) that was planted at a spacing of 45 cm× 40 cm ($B_3 \times S_4$) produced the highest net return (288922 ha^{-1}), and it was followed by ($B_3 \times S_3$) treatment combination (bulb size (75±5 g) and spacing (45 cm ×30 cm) that produced net return (285245 ha^{-1}).The seed produced from bulb size (75 ±5 g) that was planted at a spacing of 45 cm ×40 cm ($B_3 \times S_4$) had the highest benefit cost ratio (3.39), and it was followed by the ($B_3 \times S_6$) treatment combination (bulb size 75±5 g and spacing 60 cm× 40 cm) with a benefit cost ratio of 3.26.

Baghel *et al.* (2017) conducted their research at the College of Agriculture's Research Farm in Rewa, M.P. during the 2013–14 Rabi season. The goal of the study was to determine how different nitrogen levels and planting distances affected onion growth and seed yield. Four replications and a randomized block design were used to lay out the twelve treatment combinations for this investigation. For planting, healthy bulbs weighing between 40 and 60g were chosen because of their consistency in size. In this experiment, three planting spacings (closest S_1- 60cmX 10 cm, broader S_2-60cmX15 cm, and widest S_3-60cmX 20 cm) and four nitrogen levels (N_1-100 kg N ha^{-1}, N_2-120 kg N ha^{-1}, N_3-140 kg N ha^{-1}, and N_4- kg N ha^{-1}) were taken into consideration. Plant height, the number of leaves per plant, the number of days needed for fifty percent flowering, and the number of seeds produced per hectare were all significantly impacted by the varying nitrogen levels and planting spacing. The results showed that higher nitrogen doses (160 kg ha^{-1}, N_4) with the closest spacing of 60cm×10 cm (S_1) produced the highest plant height (66.77 cm), lowest number of days needed for fifty percent flowering (81.63 days), and highest seed yield (17.153 q) per hectare, while higher nitrogen doses (160 kg ha^{-1}, N_4) with the widest spacing of 60cm×20 cm (S_3) produced the most leaves per plant (59.52). The nitrogen level @ 160 kg ha^{-1} (N_4) and with spacing level of 60cmx10 cm (S_1) produced the highest net returns and cost benefit ratio (C:B ratio), which was followed by N @ 140 kg ha^{-1} (N_3) with the same level of spacing. Therefore, a larger nitrogen dose and closer plant spacing are advised for the production of onion seeds in the Madhya Pradesh area of Rewa.

The study by Nigullie and Biswas (2017) tried to determine the impact of various plant and row spacing on onion growth and yield. Eight alternative spacings were used:20cm×10cm,20cm×15cm,20cm×20cm,25cm×10cm, 25cm×15cm, 25cm×20cm, 30cm×10cm, and 30cm×15cm. Nasik Red variety was employed in the investigation. The findings showed that plant spacing had a substantial impact on onion output, yield components, and growth. Higher plant height, leaf length, and leaf count were obtained by much wider spacing. The trend toward larger spacing is also present for bulb diameter, circumference, and weight. With the widest spacing of 30cmx15cm, the weight of each onion bulb (53.0 g) increased. Adversely, the highest total yield/ha was at the closest spacing (20cm×10cm), while the lowest was at the widest spacing (30cm×15 cm).

Islam *et al.* (2015) studied the effects of spacing and fertilizer on the growth and yield of onion at the Bangladesh Agricultural Research Institute (BARI) Daulatpur, Khulna. Onion growth and yield were examined using three spacings, 10 cm × 10 cm, 15 cm × 10 cm, and 15 × by 15 cm, as well as three fertilizer combinations, soil test-based fertilizer dose (STB), integrated plant nutrient system (IPNS) based fertilizer dose, and farmers' practices. The area measured 1.5 m × 1.2 m. The spacing of 15 cm × 10 cm along with an IPNS-based fertilizer dose produced the maximum output, while 15 cm × 15 cm spacing combined with farmers' practices produced the lowest yield.

In order to investigate the effects of bulb treatment and spacing patterns on onion seed yield and quality in the semi-arid region of Ethiopia, Woldeselassie *et al.* (2014) performed research at Humbo Larena, wolaita zone, during the dry season of 2012/2013. The treatments included a factorial combination of four levels of spacing patterns (50×30×20 cm, 60×30×20 cm, 40×20 cm, and 50×20 cm) and four levels of bulb types (whole bulbs, cut (topped) bulbs, ash-treated cut (topped) bulbs, and fungicide-treated cut (topped) bulbs) that were set up in a randomized complete block design and replicated three times. A test crop of the Bombay Red onion cultivar was grown. However, there was a substantial interaction between bulb treatment and spacing that affected seed output. Planting fungicide-treated topped bulbs at both double-row spacings resulted in the best seed output. However, both single row spacings produced significantly higher values for all seed quality measures.

To ascertain the impact of planting time and spacing on the development and yield of onion variety N-53, Misra *et al*. (2014) conducted an experiment in Manipur. The treatment consisted of three replications in $1.2m^2$ plots with four different levels of spacing (S_1=15cm×20cm, S_2=10cm×20cm, S_3=15cm×10cm, and S_4=10cm×10cm) and four different planting dates (D_1=25th Nov, D_2=10thDec, D_3=25th Dec, and D_4=10th Jan.). In order to get higher productivity up to 358 q/ha for onion production in Manipur, closer spacing (10cm×10cm) and planting on November 25th were recommended practices. Planting on November 25 produced the best results, with closer spacing having higher leaf length (47.95 cm), leaf area (83.63 cm^2), leaf area index (4.21), and yield (253.40 q/ha), while wider spacing had higher leaf number (8.18 cm), average single bulb weight at harvest (56.24 g), and polar diameter (4.79 cm).

In order to understand how nitrogen and spacing affect onion development and yield, Kumar *et al.* (2014) conducted an inquiry at the Horticulture Farm, Institute of Agriculture, Visva-Bharati University, West Bengal (India) from September 2012 to March 2013. Nine treatment combinations with three amounts of nitrogen (100, 150, and 200 kg ha^{-1}) and three levels of spacing were used in the trial (10 cm x 10 cm, 15 cm x 10 cm, 15 cm x 15 cm). The experiment was set up using a factorial arrangement, randomized complete block design, and three replications. The experiment's findings revealed that the highest results for plant height, number of leaves, bulb polar diameter, and bulb equatorial diameter were obtained with an application of 200 kg N ha^{-1} and 15 cm x 15cm. The application of 150 kg N ha^{-1} together with a spacing of 15 cm x 10 cm was discovered to be the optimum combination for improving the onion production (37 t/ha) with the highest benefit-cost ratio (2.84).

Sikder *et al.* (2010) studied the effects of planting depth and spacing on the growth and productivity of two types of onions at the Horticulture farm of the Bangladesh Agricultural University in Mymensingh from October 2001 to January 2002. There were two levels of planting depth (viz., 2 cm and 4 cm) and three levels of plant spacing (i.e., 20 cm× 20 cm, 20 cm ×15 cm, and 20 cm ×10 cm). Three replications were used in the RCBD design of the experiment. Most growth and yield parameters were significantly impacted by plant spacing While closer spacing provided the highest output of bulb (12.08 t/ha), wider spacing produced the most leaves per plant, longest plant height, maximum width, and fresh weight of the bulb. At a shallower planting depth, bulb yield was markedly higher. On the majority of the growth and yield characteristics, it was discovered that the combined effects of planting depth and spacing were substantial. In comparison to other treatment combinations, the

20cm × 10cm spacing and 2 cm depth of planting resulted in a significantly greater yield (12.82 t/ha).

According to Devi *et al.* (2008), larger bulbs and closer spacing (10cmx10cm) produced the highest yield of onions (B_3). The largest output (184 quintal per ha) was recorded in closer spacing (20cmx10cm), however this spacing also recorded the most leaves per hill, bulbs per hill, and most bulb features (10cm x 10cm). The number of leaves per hill, the length of the leaves, and the characteristics of the bulbs are all strongly influenced by bulb size.

In order to determine the effects of bulb size (1.5, 3.0, and 4.5 cm diameter) and plant spacing (30cm×10cm, 30cm×15cm, 30cm×20cm) on the production of onion seeds, Singh and Ahmed (2005) conducted an experiment in Ladakh, Jammu and Kashmir, India in the winter of 2002-2003. The largest plant height was seen in bulbs planted at a spacing of 30 by 10 cm that had a diameter of 4.5 cm, while the smallest bulbs and those with the widest spacing had the lowest plant heights. The greatest bulb size and widest spacing produced the highest number of sprouts per hill, umbels, and seeds per umbel. When medium-sized bulbs were planted at 30cm×20cm, the highest average seed yields (10.50 and 11.20q/ha) were noted. The treatment had no impact on seed germination.

In order to investigate how spacing and bulb size affect onion cv. Sukhsagar growth and seed yield, Umesh-Thapa (2004) conducted a field experiment in West Bengal, India, during 2000–2001. The evaluation included three spacing combinations (30x30, 45x30, and 50x30 cm) and three bulb sizes (15-25, 30-45, and 50-65 g). The plant height and scape length, number of days till 50% flowering, and seed yield/ha were all significantly impacted by the highest spacing of 30 cm x 30 cm.All growth- and yield-related aspects were significantly impacted by bulb size as well (plant height, number of leaves per plant, length of leaves, number of scapes per plant, height and diameter of scape, number of umbels per plant, diameter of umbel, number of days to 50 percent flowering and 1000-seed weight). The bulb size of 50–65 g produced the maximum seed yield (12.5 quintal/ha; a quintal is lOO kg).

According to Jilani *et al*. (2004), onion plants with the lowest plant population (20 plant m^{-2}) had the most leaves and the longest leaves.

Ushakumari *et al.* (2000) experimented with several plant spacings (10 x 10, 15 x 10, and 20 x 10 cm) and discovered that the smaller the spacing, the greater the total bulb yield, dry matter, leaf area index, and crop growth rate.

According to Ali *et al*. (1998), reported plants separated at a distance of 10 cm produced the highest yield per hectare (335.65 kg), followed by those at a distance of 30 cm (296.53kg). They planted bulbs spaced at 10, 15, 20, 25, and 30 cm intervals. Additionally, they discovered that plants spread at 30 cm had 1000 seed weight (2.12 g), which was much higher than plants spaced at 10 cm (1.48g).

Plant spacing had no significant influence on the percentage of seeds that germinated, according to Singh and Sachan (1998).

In a field experiment conducted in Junagadh, Gujarat, India during the rabi season of 1994–1955, Dadhania *et al.* (1998) investigated different combinations of four bulb diameters (1.6–2.5 cm, B_1; 2.6–3.5 cm, B_2; 3.6–4.5 cm, B_3; or 4.6–5.5 cm, B_4) and plant spacing (30 x 30cm, S_1; 45 x 30cm, S_2; 60 x 30cm, S_3; or 60 x 45cm, S_4). Plant height, scape count, and seed yield observations were made. B_4S_3 and B_4S_4 respectively recorded the maximum plant height (58.60 cm) and scape number (7.0). The plants from B_3S_3 and B_1S_1 had the largest (28.80 g) and lowest (10.13 g) seed yields, respectively. The crop from B_4S_1 produced the highest seed production per hectare (21.85 q).

Rajas *et al*. (1993) found that onion Cv. Pusa Red produced the highest yield (28.11 t/ha) with a plant spacing of 10 cm x 15 cm (15 cm x 15 cm; 20 cm x 15 cm).

Umbel diameter was unaffected by plant spacing (Nehra *et al*.,1988 and Pandey *et al.*, 1992). The largest umbels were produced by the widest spacing (Singh and Sachan, 1999).

Wider spacing increased the quantity of flower stalks per plant (Nehra *et al.*,1988; Bhardwaj,1991; Dadhania, 1998 and Singh and Sachan, 1999). The final seed output increased with wider plant spacing because it produced more flowering stalks per unit area (Steiner, 1986). The topmost number of flowering stalks per plant was created. When the space is closed (Lal *et al.*1987).

2.2. Effect of fertilizer on growth and yield of bunching onion

In order to study the impact of spacing and fertilizer amendment on onion growth and seed yield, Khayer (2017) conducted an experiment at SAU, Dhaka, Bangladesh from October 2017 to April 2018. In an RCBD with three replications, four levels of spacing (S_1= 20cm×15cm, S_2=25cm×15cm, S_3=20cm×20cm, and S_4=25cm×20cm) and four levels of fertilizer (T_0=control, T_1=$N_{60}P_{30}K_{80}S_{20}$kg/ha, T_2=$N_{80}P_{50}K_{100}S_{30}$ kg/ha, and T_3=$N_{100}P_{70}K_{120}$ The $N_{80}P_{50}K_{100}S_{30}$ kg/ha treatment produced the highest seed production per ha (404.20 kg) when seeds were spaced 20cm×15cm apart. $N_{80}P_{50}K_{100}S_{30}$ kg/ha had the largest plant height, number of leaves, bulb diameter, length, and weight, as well as the maximum seed yield per plot, yield per hectare, number of flowers per umbel, and weight of 1000 seeds.

Majkowska *et al.* (2016) were investigate the effect of polimag S on the yield and nutritional value of the welsh onion (*Allium fistulosum* L.) in NE Poland. The experiment factor were 1) welsh onion cultivars Long White Ishikura, Parade and Performer grown from seedlings, and 2) the application of a mixed fertilizer, polimag S,at two doses of 0.72 t/ha and 1.44 t/ha. The welsh onion cultivars analyzed did not differ significantly with respect to yield. The total yield of welsh onions did not increase significantly as the dose of polimag S was increased from 0.72 t/ha to 1.44 t/ha which indicates that increased fertilizer use was economically unjustified. The lowest welsh onion yield was obtained in the control treatments.

Shi *et al*. (2015) conducted an experiment to find out the effect of NPK combined application on the yield, nutrition absorption and utilization characteristics of *Allium fistulosum*. The results showed that the growth and NPK absorption of *A.fistulosum* under the balanced fertilization treatment ($N_2P_2K_2$) were significantly higher than other elements deficiency fertilization treatments such as $N_0P_2K_2$, $N_2P_0K_2$, N_2P_2K. Compared with $N_0P_0K_0$, the yield of the element's deficiency treatments were increased significantly, but their yield reduced 35.66%,23.37%, and 33.50% respectively compared with $N_2P_2K_2$.The results indicated that nitrogen had the biggest effect on *A.fistulosum* yield formation, and potassium and phosphorus followed by.NPK fertilization combined was beneficial to improve the yield and fertilizer utilization rate of *A.fistulosum*..

Meena *et al*. (2015) carried out an experiment in Kharif, 2012, with 18 treatment combinations, including three bio-fertilizer treatments (without inoculation, *Azospirillium*, and *Azospirillium* + PSB), six levels of organic manures (Control, FYM @ 10 t ha^{-1}, vermicompost @ 5 t ha^{-1}, poultry manure @ 5 t ha^{-1}, FYM @ 5 t ha^{-1} + vermicompost. The combined application of FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1}, according to the results, considerably boosted growth characteristics, TSS, and nitrogen content in bulb. While the treatment of FYM at 5 t ha^{-1} plus poultry manure at 2.5 t ha^{-1} dramatically boosted the phosphorus and sulfur content of the bulb. When compared to alternative treatments, bulb inoculation with *Azospirillium* + PSB dramatically boosted both growth and quality features.

Kolota *et al.* (2013) conducted a field trial to determine the response of Japanese bunching onion (*Allium fistulosum* L.) to nitrogen fertilization. In two factorial field experiment, calcium nitrate, ammonium nitrate and Entec 26 nitrogen Mineral fertilizer containing DMPP nitrification inhibitor used as the source of N and applied at the rates of 75,150 and 225 kg/ha were compared. The yield and nutritional value of edible parts expressed by the content of dry matter, vitamin C, total chlorophyll, carotenoids, volatile oils, total N, NO_3, N, P, K, Ca and Mg were estimated. The use of Entec 26 was associated with higher amounts of total chlorophyll and carotenoids in edible part of plants compared to commonly recommended ammonium nitrate and similar to calcium nitrate. The increment of preplant nitrogen rate from 75 to 150 and 225 kg/ha did not affect the crop yield and significantly enhanced the nitrates accumulation in plants at harvest. To study the response of green onion crop for some kinds of organic fertilizers field experiment was conducted in the vegetables field of the Department of plant production in Agricultural Technical College /Mosul in Rashidiya during 2012-2013 season where the green onion bulblets planted in 14 th Oct 2012 in boards on lines dimensions of 40cm and the distance between plants

20 cm and the experiment included six treatments (chemical fertilizer 65 kg/D urea + 65 kg/D superphosphate + 50 kg/ D potassium sulphate and poultry manure at rate of 15 cubic m/D and sheep manure at rates of 20 cubic m/D and three treatments of manufacture poultry manure (Italpollina) at 20,30 and 40 kg/ 100 m^2 and carried out in RCBD with 5 replicates.The findings demonstrated the superiority of poultry manure supplied at a rate of 40 kg/100 m^2. In some yield characteristics (yield per plant 338.61 g and total yield 12697 kg/D) as well as in some vegetable growth characteristics (leaves number per plant 27.62, leaves fresh weight 93.23 gm, leaves dry weight 11.53 gm). (Khalel,2013).

An experiment was conducted by Mishu *et al.* (2013) to examine the impact of various sulphur doses on onion growth and yield performances. Five levels of sulfur were used in the experiment (0, 20, 40, 60 and 80 kg S ha^{-1}). With the application of sulphur fertilizer, individual onion bulb weight, bulb yield, dry weight of root, dry weight of bulb, dry weight of shoot, and dry weight of leaf, as well as total dry matter (TDM), leaf area index (LAI), absolute growth rate (AGR), relative growth rate (RGR), net assimilation rate (NAR), and dry weight of each individual onion bulb, all increased significantly. Among the various sulphur doses, application of 40 kg S ha^{-1} produced the maximum yield (10.65 t ha^{-1}).

The growth and yield of kharif onions under rainfed conditions were examined in an experiment by Naik and Hosamani (2013) to determine the impact of spacing (15 ×10 cm, 15 ×15 cm, and 15× 20 cm) and N levels (0.50, 100, and 150 kg/ha).For improving production (16.90 t/ha), as well as other growth and quality parameters like plant height, leaf number per plant, bulb length, bulb diameter, and bulb total soluble solid content, a narrow spacing of 15 ×10 cm with an application of 150 kg N/ha was determined to be optimal. T_4 (50 percent vermicompost + 50 percent NPK) proved to be the most effective fertilizer treatment for the majority of the attributes in terms of fertilizer treatments. The maximum plant height, polar and equatorial diameter, and weight of the bulbs were all recorded. The maximum bulb yield (353.80 q/ha) was also produced using the same technique.It has been determined that using organic inputs along with chemical fertilizer is preferable to applying organic manure or chemical fertilizer alone. This would not only increase the farmers' financial gain and revenue generation, but it will also lower the rising onion market prices in the nation.

In hydroponics using Hoagland's solution, the effects of nitrogen and sulphur ($N_{3.75}S_{0.35}$, $N_{3.75}S_{4.2}$, $N_{7.5}S_{1.4}$, and $N_{22.5}S_{0.35}$) mmol/L on bunching onion growth and quality were investigated. The outcomes demonstrated that the $N_{7.5}S_{1.4}$ treatment produced superior bunching onion growth than other treatments. The growth of bunching onions was enhanced at the same sulphur level with rising N, while the growth of bunching onions was increased by sulphur at the same nitrogen level.The $N_{7.5}S_{1.4}$ treatment had the highest concentrations of chlorophyll a, b, total chlorophyll, and carotenoids. In bunching onion, the concentration of soluble protein and nitrate increased as nitrogen and sulphur increase, whereas the concentration of soluble sugar decreased as nitrogen increased. (Zhang and Jin, 2011).

Sun *et al*., (2012) conducted a trial to determine the effects of different NH_4^+-N to NO_3 -N ratio (NH_4^+ /NO_3^-) (0,1/8,1/4 and 1/2) on growth and quality of bunching onion (*Allium fistulosum* L.) under high temperature stress (34°C/26°C day/ night) were studied in growth chamber by hydrophonics. The results showed that the growth and quality of bunching onion were affected by NH_4^+/NO_3^-. Plant weight and height, leaves number per plant were highest in the treatment which NH_4^+/NO_3 was 1/8, and those in treatment without NH_4^+N were higher than all other treatments. The concentration of vitamin C was the highest in the treatment which NH_4^+/NO_3 was 1/8. The growth and quality of bunching onion were better in the NH_4^+/NO_3 range of 1/8 to 1/4.

Adewale *et al*. (2011) evaluated the impact of various rates of poultry manure on the output of garlic. Five different rates of poultry manure (0. 5.10.15.20 t/ha) were compared. The yield of the control produced the lowest yield. All of the treatments produced yields that were noticeably higher than the control. The plants that got poultry manure had the highest yield, which was 20 t/ha. This could be related to the higher nutritional quality of the poultry feces at this rate.

In order to determine the ideal mixture of compost and inorganic fertilizer that would produce an economically viable yield of onions, Seran *et al*. (2010) conducted an experiment. The recommended dosage of inorganic fertilizers was used as the control

(T_1), followed by compost alone (8 t ha^{-1}), 34-fold of the control treatment Plus compost (2 t ha^{-1}), 12-fold of the control treatment + compost (4 t ha^{-1}), and 14-fold of the control treatment + compost (6 t ha^{-1}) (T_5). In this experiment, they served as the foundational fertilizer application. The findings of this study showed that, throughout the early stages of growth, there were significant ($P_{0.05}$) differences in the numbers of leaves and roots across the various treatments. The plants treated with inorganic fertilizers alone (T_1) had a somewhat greater yield (5.03 t ha-1), whereas compost alone (T_5) produced the lowest yield (3.43 t ha-1). Additionally, it was discovered that neither the yields between T_1 and T_2 nor T_1 and T_3 differed significantly ($P>0.05$). The gradual release of nutrients from the compost by the inorganic fertilizers seems to have made up for this, and their combined impacts would have enhanced the yield. The gradual release of nutrients from the compost by the inorganic fertilizers seems to have compensated for this, and their combined impacts would have enhanced the yield. According to the results of this study, using compost and inorganic fertilizer at a rate of 4 t ha^{-1} (T_3) might produce a profitable yield of 4.75 t ha^{-1}, and this combination may lower the cost of production when growing onions.

Liu *et al*.wqa (2009) conducted an experiment to determine the effect of nitrogen and sulphur interaction on growth and pungency of different pseudo stem types of Chinese spring onion (*Allium fistulosum* L.) in soilless growing media. In the first experiment the effects of S supply (0.01and 4.00 $mmolL^{-1}$ $SO_4{}^{2-}$) on the growth and pungency of Chinese spring onion were investigated among four cultivars with fleshy root type. In the second experiment the effects of different S (0.01 and 4.00 $mmolL^{-1}SO_4{}^{2-}$) and N (1.5,3.0,6.0, 12.0 and 24.0 $mmolL^{-1}$ N) supply levels on the growth and pungency of Chinese spring onion were studied. Fleshly root spring onion had stronger pungency and larger pseudo stem diameter than long pseudo stem spring onion, and the pungency of fleshy root spring onion was regulated to a greater extent by N and S supply compared with long pseudo stem spring onion. The biomass of chinese spring onion of fleshy root type and long root type was more influenced by N supply than it was by cultivar or S supply. Low Sulphur with increasing N supply decreased the pungency of two cultivar. Excessive N supply (24 $mmolL^{-1}$) significantly inhibited plant growth, retarded S assimilation and decreased pungency. It is therefore essential to apply the optimum recommended rate of N fertiliser in chiness spring onion production.

A field experiment studied the effects of spacing and potassium on the growth and yield of summer onions, Huque (2008) described a field experiment at the Sher-e-Bangla Agricultural University Farm in Dhaka (*Allium cepa*). She discovered that summer onions grew and produced at their maximum levels when fertilized with potassium at a rate of 120 kg/ha.

During the 2004–2005 growing season, a study was conducted at Rajshahi University's Botanical Garden Field in Bangladesh to examine the impact of nitrogen and potassium levels on onion yield and seed quality production. A. Four nitrogen level of 0,50,100,150 kg/ha and B.Four potassium level of 0,40,80,120 kg/ha were both taken into account. The outcomes demonstrated that various treatments had a substantial impact on plant height, tillers, flowers, seeded fruits, fruit set, days to blooming, seed output, and germination %. The treatment combination at level NK (150,120 kg/ha) generated the highest yield of seed per ha (515.42 kg/ha), followed by treatment combinations of 100 kg N/ha with 120 kg K/ha and 150 kg N/ha with 40,80 kg K/ha, respectively. (Ali *et al.* 2007).

A study was conducted by Yamasaki *et al*. (2005) to determine how N affected the welsh onion (*Allium fistulosum*) cv. Kincho's growth and blotting. They observed how N affected the crop's blossom initiation.Welsh onions' development was slowed down by low N levels, but their leaf sheath bulbing was encouraged. Additionally, it decreased the concentration of N and C while raising the crop's C:N ratio. In plants subjected to cold temperatures for 35 days, low nitrogen encouraged bolting.

Welsh onion yield improved by 3.1-24.4 percent (34.6-270.9 kg/666.7 m^2) when 20 kg N, P, and K were applied, whereas the yield of the crop increased by 14.2-32 percent when organic fertilizer was applied topically (186-425.9 kg1666.7 m^2) Welsh onion yield improved by 3.1-24.4 percent (34.6-270.9 kg/666.7 m^2) when 20 kg N, P, and K were applied, whereas the yield of the crop increased by 14.2-32 percent when organic fertilizer was applied topically (186-425.9 kg1666.7 m^2). (Qiao-llongXia *et al.* 2005).

In a study conducted in Ripura, India during Rahi 2001, Mandira and Khan (2003) conducted an experiment with different levels of nitrogen (0. 100, 150, and 200 kg ha^{-1}) and potassium (0. 75 and 150 kg /ha given as soil application) to study their effect on the growth, yield, and yield attributes of onion cv. N-53. Nitrogen at 150 kg /ha. potassium at 75 kg/ ha S and their combination recorded the best performance in terms of yield and growth. All other treatments and their combinations were superior to control.

Sustainable crop production was reported by Nambiar *et al.* (1998) with the combined application of organic manure and chemical fertilizers. For a sustainable agriculture to produce high-quality real onion seeds, an appropriate blend of organic and inorganic nutrient sources is required. The combined use of chemical and organic fertilizers would be highly beneficial for sustaining higher soil fertility levels as well as greater production stability.

Rahim *et al*. (1997) reported that the plant receiving the highest rates of N and K yielded the most tillers per plant, flower stalks per plant, flowers per umbel, fruits per umbel, seed yield per plot, and seed yield per hectare (508 kg/ha). This treatment combination (100kgN/ha160kgK_2O/ha) produced the highest seed yield.

CHAPTER III
MATERIALS AND METHOD

A field experiment was conducted to study the effect of plant spacing and fertilizers on the growth and seed yield of bunching onion during the period from 15 November, 2020 to 30 April, 2021. The details of the experimental materials and methods used in this experiment have been described below.

3.1. Site Description

3.1.1. Geographical Location

The research work was conducted at the Central farm of Sher-e-Bangla agricultural University, Sher-e-Bangla Nagar, Dhaka-1207.The experimental area was situated at 23°77´N and 90^{0} 35´E longitude at an altitude of 8.6 meter above the sea level.

3.1.2. Agro-Ecological Zone.

The experimental field is a part of "The Modhupur Tract's" Agro-Ecological Zone 28, or AEZ-28. Over the Modhupur clay, this area had complex relief and soils that developed. Floodplain sediments buried the Modhupur tract's dissected edges, leaving small hillocks of red soil that served as "islands" surrounded by floodplain. In Appendix I's map of Bangladesh's AEZ, the trial site is indicated.

3.1.3. Soil

Shallow Red Brown Terrace soils under the Tejgaon series are the overall soil type to which the soil at the trial site belongs. The pH of the soil was 7.1, and 1.08 percent of it was organic. The test location was level, had a drainage and irrigation system, and was above flood level. From experimental fields, soil samples between 0 and 15 cm deep were collected. Soil Resource and Development Institute (SRDI), Dhaka, performed the soil analyses. In Appendix II, the soil's chemical characteristics are listed.

3.1.4. Climate

The experimental site's geographic position lay under a subtropical climate with three different seasons: winter from November to February, hot season or pre-monsoon from March to April, and monsoon from May to October. The Sher-e-Bangla Nagar Weather Station in Bangladesh provided the high accuracy of air temperature, relative humidity, rainfall, and sunshine hour during the experiment. These measurements are detailed in Appendix III.

3.2. Planting Material

Seed was collected from regional spices research center, BARI, Gazipur. The variety produced plants 50-90 cm tall with 5-13 leaves plant^{-1}. The leaves contained 9-11% dry matter. The umbel diameter 3-7cm and yield of seed 8-12 ton/ha. The germination of the seed was 85%.

3.3. Experimental Details

3.3.1. Treatments

The experiment comprised as two factors

Factor A: plant spacing (3 levels of plant spacing)

i. S_1: 20cm×10 cm

ii. S_2: 20cm×15 cm

iii. S_3: 20cm×20 cm

Factor B: Fertilizer (4 levels of inorganic and organic fertilizer combination)

i. $F_{0:}$ Control

ii. F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$

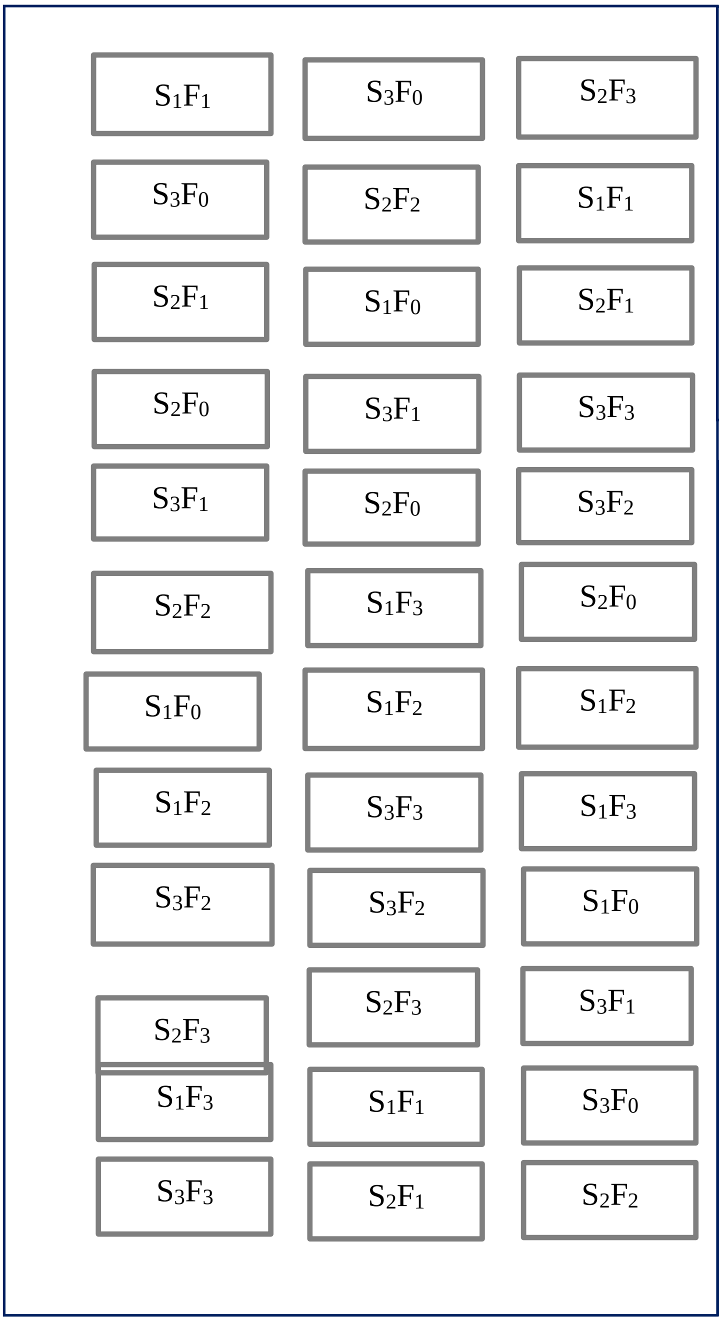
iii. F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$

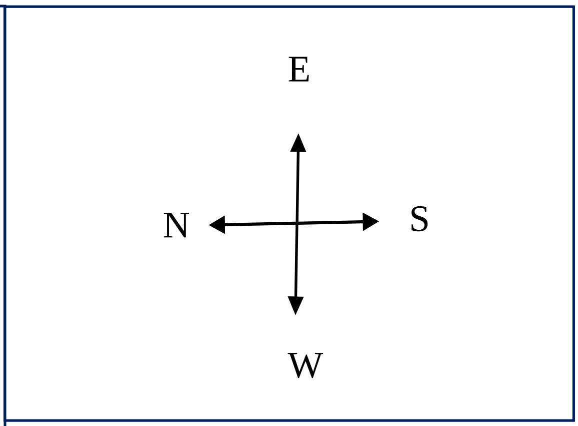
iv. F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

There were 12 (4 × 3) treatment combination $S_1F_{0,}$ S_1F_1, S_1F_2, S_1F_3, S_2F_0, S_2F_1, S_2F_2, S_2F_3, S_3F_0, S_3F_1, S_3F_2, S_3F_3.

3.3.2. Experimental Design and Layout

The experiment was laid out in Randomized Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of plant spacing and fertilizers. The 12 treatment combinations of the experiment were assigned at 36 plots. The size of each unit plot is (1.2×1.2) m^2. The spacing between blocks and plots were 1.0 m and 0.5 m, respectively.





Treatments:

Factor A: Plant Spacing

i. $S_{1:}$ 20 cm ×10 cm
ii. S_2 20 cm ×15 cm
iii. $S_{3:}$ 20 cm ×20 cm

Factor B: Fertilizer

F_0: Control
F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$
F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$
F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

Experimental Layout:

Total number of unit plots: 12 × 3 = 36
Unit plot size: 1.2 m×1.2 m = 1.44 m^2
the main plot and unit plots were separated by 1m and 0.5m, respectively.

Figure 1. Field Layout of two factors experiment in the Randomized Complete Block Design (RCBD).

3.4. Growing of Crops

3.4.1. Seed bed preparation

The land selected for raising seedlings was fine texture and well drained. The land was opened and drying for 10 days. Large sized clods were broken into pieces and finally the soil was made loose, friable, until good tilts. All weeds and stubbles were removed and the soil was mixed with decomposed cow dung during final land preparation. Applying Furadan 3 G @ 20 kg ha^{-1} was covered by polythene for two days. The seed bed was 3m × 1 m in size with a height of about 20 cm. Onion seeds were soaked overnight (twelve hours) in water and allowed to sprout in a piece of moist cloth keeping in the sunshade for one day.

3.4.2. Seed sowing

The first seed was sown on November 15, 2020. In order to develop seedlings that will be transplanted, the seeds were directly sown in the raised seed bed. The immature seedlings were exposed to morning and evening mid sun and nighttime dew. To keep the soil moist and protect the seedlings from the sun and rain, shade was placed over the seed beds.

Plate 1. Image of seed germination under polythene sheet

3.4.3. Land Preparation

On November 20, 2020, the ground was first plowed using a tractor-drawn disc harrow before being cross-plowed four times with a power tiller and ladder. The land's edges were spaded. After that, the soil was harrowed to improve its tilth. A ladder was used to completely level the ground. The field was cleared of weeds and stubbles. The clods were all broken up into little bits. Before sowing, the unit plots were also expertly prepared with a spade.

Plate 2. Image of Land preparation

3.4.4. Fertilizers

250kg urea, 275kg TSP,150kg MP and 110kg Gypsum were recommended by regional spices research center, BARI for one hacter bunching onion cultivation. Fertilizers were used in the experiment according to as per treatment.

3.4.5. Application of fertilizers and manure

Full amount of TSP and full amount of Gypsum were applied in the field as basal dose as per treatment during final land preparation. Urea, Mop, Vermicompost and Poultry manure were applied as top dressing in 3 equal splits at 15 days intervals.

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

Organic and Inorganic Fertilizer	Dose /ha	Dose for F_1 Treatment	Dose for F_2 Treatment	Dose for F_3 Treatment
Urea	250 kg	18 g	18 g	36 g
Triple super phosphate (TSP)	275 Kg	19.8 g	19.8 g	39.6 g
Muriate of Potash (MP)	150 Kg	10.8 g	10.8 g	21.6 g
Gypsum	110 Kg	7.92 g	7.92 g	15.84 g
Vermicompost	6ton	864 g	-	432 g
Poultry Manure	6ton	-	864 g	432 g

Table 2. Nutrient content of different sources of organic and inorganic fertilizer

Sources of Nutrients	Nutrient content of different organic and inorganic fertilizer			
	N_2%	P_2O_5%	K_2O	S
Urea	46	-	-	-
TSP	-	48	-	-
MP	-	-	60	-
Gypsum	-	-	-	18.6
Vermicompost	2.3%	5.68-8.25	2.62-3.2	-
Poultry Manure	4.5-5.26	9.02-10.34	2.87- 3.3	-

Plate 3. Image of fertilizer application

3.4.6. Transplanting of seedlings

Healthy and disease-free uniform sized 40 days old seedlings were uprooted from the seed beds and transplanted in the main field with the line to line of spacing as per treatment in the afternoon on 25 December 2020. Before removing the seedlings, the seedbed was irrigated to reduce root damage. After transplantation, the plants were immediately given water. Additionally, several seedlings were transplanted close to the experimental area to cover any gaps.

Plate 4. Image of transplanting of seedlings

3.5. Intercultural Operations

3.5.1. Gap filling

Within a week of transplantation, damaged or dead seedlings were replaced by healthy plants.

3.5.2. Weeding and mulching

Weeding was done three times after transplanting to keep the crop free from weeds and mulching was done by breaking the crust of the soil for easy aeration and to conserve soil moisture, when needed especially after irrigation.

3.5.3. Irrigation and drainage

Irrigation was given when needed. First irrigation was given just after transplanting and also at 20 days after transplanting. During this time care was taken so that irrigated water could not pass from one plot to another. During each irrigation, the soil was made saturated with water. After rainfall excess water was drained out when necessary.

3.5.4. Plant Protection

The bunch onion crops were normally found to be resistant to purple blotch disease caused by *Alternaria porri*. Therefore, preventive measure was taken by spraying Ridomil MZ68 WP @ 2g L^{-1} of water at 20 DAT to keep the crops free from diseases. Second spraying was done with Dithen M-45 @ 2g per Liter of water and malathion 57 [2 ml L^{-1} of water to control onion thrips (Thrips sp.) at 45 days after planting (DAT). Third spraying was done with Rovral 50 WP (2g L^{-1} of water) at 60 days (DAT) to keep the diseases under control.

3.5.5. Stalking

Stalking was provided in each plot using bamboo and rope, to keep the plot erect and to protect them from the damage caused by storms and heavy winds.

Plate 5. Image of stalking the plot

3.6. Harvesting and Sampling

The matured umbels were harvested in 28th March when the fruit had black seed exposed. Umbels were harvested with a small portion of flowering stalk in the morning to prevent shattering of seeds. The harvesting continued upto to 30 April, 2021.

Plate 6. Image of harvesting matures umbel

3.7. Threshing, Cleaning, Drying and Storage

The harvested bunching onion umbels were dried in the sun on a cement floor. When the capsules and tiny stems of the umbels were fragile and easily broke when rubbed between the hands, the umbels were ready for threshing. By hitting the umbels with a little stick, the seeds were crushed. Following hand winnowing, seeds were cleaned, put in the open sun on brown paper, and dried until their moisture level was safe (6-9 percent). The seeds were sealed in airtight polythene bags and stored at room temperature in a dry, cool environment.

Plate 7. Image of drying the mature umbels

3.8. Weighing

The seeds thus collected were dried in the sun for reducing the moisture in the seeds to a constant level. The dried seeds and straw were cleaned and weighed.

3.9. Seed Quality

The seeds collected from the field experiment were divided up. These seeds were used in scientific trials to determine product quality. Standard germination tests were carried out for this purpose, and data on several quality features were collected.

3.10. Data Collection

3.11. Procedure of Recording Data

3.11.1. Plant Height (cm)

The height of the 10 randomly selected plant was measured from the ground level to the tip of the largest leaf at 25 DAT, 50 DAT, 75 DAT and 100 DAT. Mean highest was them calculated.

3.11.2 Number of Leaves Plant^{-1}

Total number of leaves was counted from the 10 randomly selected plants at 25 DAT, 50 DAT, 75 DAT and 100 DAT and the mean of total number of leaves was then taken.

3.11.3. Number of Umbels Plant^{-1}

Number of umbel plant^{-1} was counted from the 10 randomly selected plant sample and then the average umbel number was calculated.

3.11.4. Umbel Diameter (cm)

Umbel diameter was measured by a meter scale from 10 randomly selected umbels of plants and then the average umbel diameter was calculated.

3.11.5. Number of Seeds Umbel^{-1}

Number of seeds per umbel was counted from 10 randomly selected umbels of plants and then the average seed number was calculated.

3.11.6. Weight of 1000 Seeds (g)

1000 seeds were counted, which were taken from the seeds sample of each plot separately, then weighed in an electrical balance and data were recorded.

3.11.7. Seed Yield

3.11.7.1. Yield of Seeds Plant^{-1} (g)

The 10 plants selected at random from the inner rows of each plot were harvest to take seed yield per plant. The seed were threshed, cleaned, weighed and then averaged the seed yield in g plant^{-1}.

3.11.7.2. Yield of Seeds Plot^{-1} (g)

All plots were harvested individually and the average yield of seeds plot^{-1} was recorded.

3.11.7.3. Yield of Seeds ha^{-1} (kg).

The yield of seed in g per plot was adjusted at 12% moisture content of seed and then it was converted to kg per hectare.

3.11.8. Total Germination (TG %)

Total germination (TG) was calculated as the number of seeds which was germinated within 15 days as a proportion of number of seeds set for germination test in each treatment.

TG (%) = $Number\ of germinated\ seeds\ /\ Total$ number of $seeds\ set\ for\ germination$ x 100

3.12. Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatments by using the Statistix-10 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 Different Test (LSD) at 5% level of probability.

3.13. Economic analysis

The cost of production was analyzed in order to find out the most economic treatment of NPK fertilizer, vermicompost and poultry manure for quality seed production of bunching onion. All the non-material and material input costs and interests on running capital were considered for computing the cost of production. The interests were calculated for six months @ 14% per year. The price of one kg bunching onion seed was considered to be Tk. 1500.

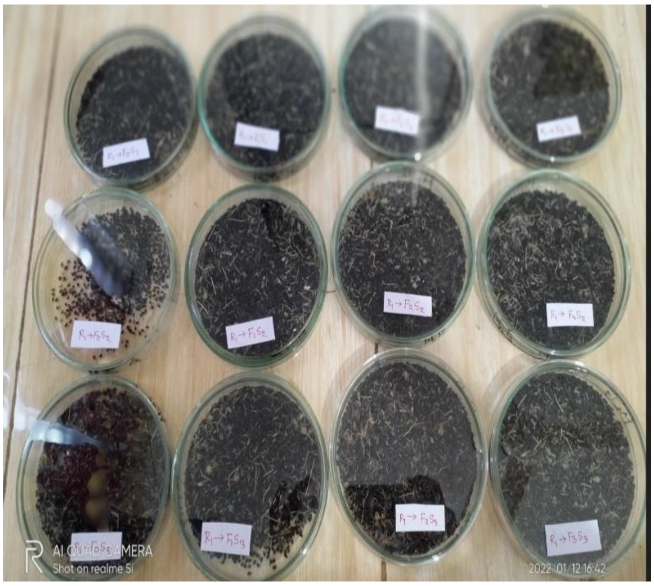
The benefit cost ratio (BCR) was calculated by the following formula:

Gross return (Tk /ha)/Benefit cost ratio (BCR) = Total cost of production (Tk /ha)

(a)

(b)

(c)



(d)

Plate 8. a) Image of flower bud initiation; b) Image of pollination of flower; c) Image of bunching onion plant after harvesting; d) Images from different treatment combinations;

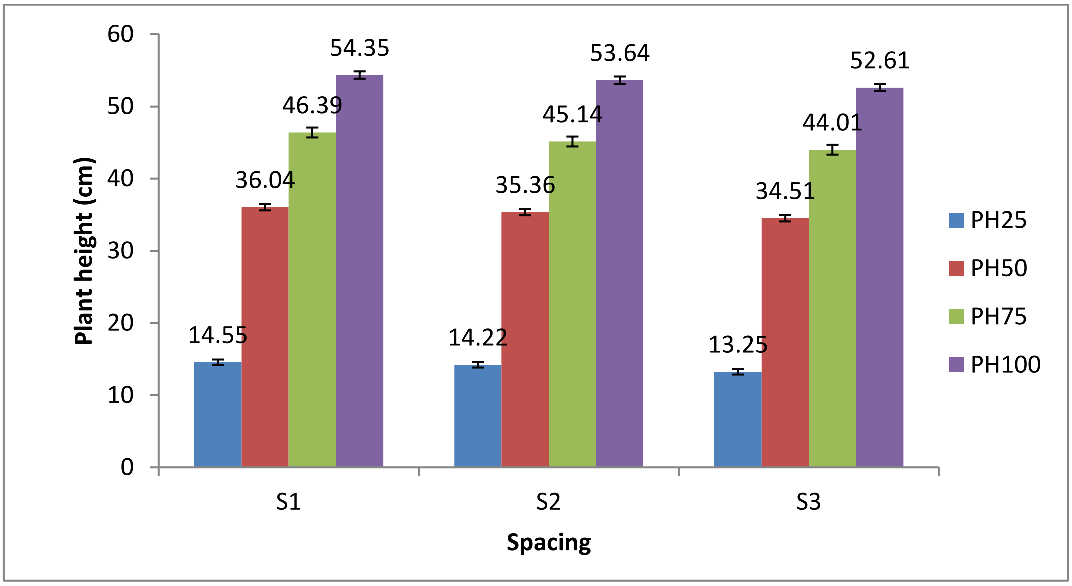
CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to investigate the growth and seed yield of bunching onion influenced by plant density and fertilizer. Data on different parameters were analyzed statistically and results have been presented in tables 3 to 9 and figures 2 to 4. The results of the present study have been presented and discussed in this chapter under the following heading.

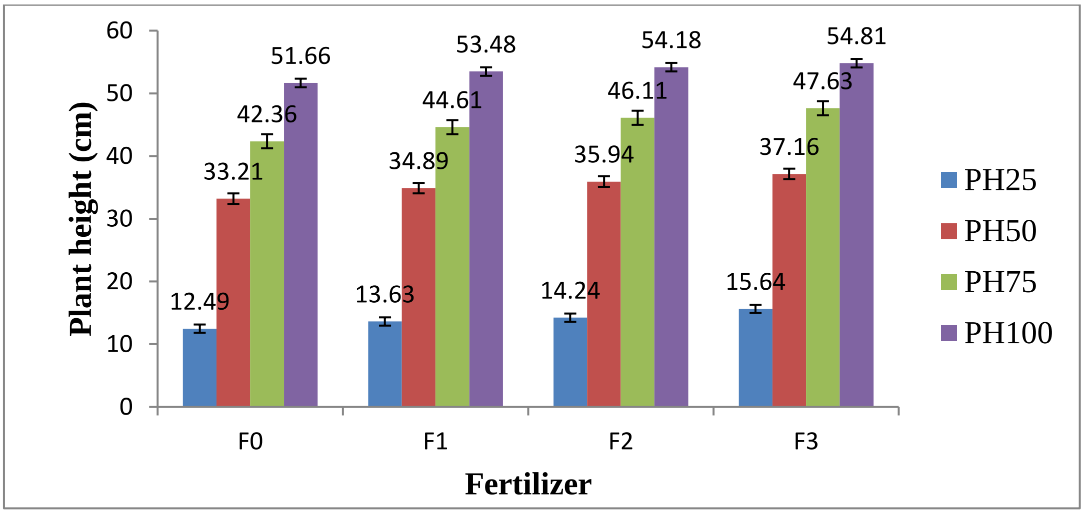
4.1 Plant height (cm)

Plant height is an important vegetative growth parameter which reflects the yield of bunching onion plant (Fig.2 and Appendix IV). It was observed that plant height was significantly influenced by different plant spacing at 25,50, 75 and 100 DAT. Results revealed that the maximum plant height (54.35cm) was measured at 100 DAT was from S_1 (20cm × 10cm) followed by S_2 (20cm ×15 cm). On the other hand, the minimum plant height (52.61cm) at 100 DAT was recorded from S_3 (20cm ×20 cm) treatment. The plant height was decreased with increasing in row spacing. The increased plant height at closer spacing was due to more competition for air and light. Similar result was found from Harun-or-Rashid (1998), he narrated that the closest spacing produced the highest plant height which was supported by Mostakim *et al.* (2000). But Khushk *et al.* (1990) observed that wider inter and intra row spacing significantly increased plant height which was also confirmed by Pandey *et al.* (1999). The experiment was significantly influence for the variation of different levels of fertilizer application on plant height of bunching onion at different days after transplanting (DAT) (Fig.3 and Appendix IV). It was found that there was significant effect on plant height among the treatments at 25, 50, 75 and 100 DAT. The maximum plant height was measured (54.81cm) at 100 DAT was measured from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$), treatment followed by F_2 ($N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$) treatment where the shortest plants (51.66 cm) was measured from F_0 = Control treatment at 100 DAT. The plant height increased with increasing fertilizer at certain level.



Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20 cm

Figure 2. Effect of spacing on plant height (cm) of bunching onion (*Allium fistulosum* L.)



F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3:$N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

Figure 3. Effect of different levels of fertilizer on plant height (cm) of bunching onion (*Allium fistulosum* L.)

Vacchani and Patel (1993) reported that the height of plant increased with increasing levels of nutrients. The result might be due to the fact that vermicompost enhances the vegetative growth of bunching onion. The present findings are agreed with the findings of Yadav *et al*. (2015) and Meena *et al*. (2015).

Due to combined effects of different spacing and fertilizers treatment showed significant variation on plant height. The highest plant height (55.95cm) was obtained from S_1F_3 (20cm×10cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment while the lowest plant height (49.82cm) was obtained from the treatment of S_3F_0 (20cm×20cm and control) treatment combination (Table 3).

Table 3. Combined effects of spacing and fertilizer on plant height (cm) of bunching onion (*Allium fistulosum* L.)

Treatment	Plant height (cm) at			
	25 DAT	**50 DAT**	**75 DAT**	**100 DAT**
S_1F_0	12.98 d	33.75 f	44.43 e	53.14 e
S_1F_1	14.06 bc	35.46 cde	44.90 cde	53.88 cd
S_1F_2	14.36 b	36.40 bc	46.51 bc	54.42 bc
S_1F_3	16.82 a	38.54 a	49.71 a	55.95 a
S_2F_0	12.95 d	33.74 f	42.60 f	52.02 f
S_2F_1	13.58 bcd	34.77 ef	44.70 de	53.70 d
S_2F_2	14.32 b	36.12 bcd	46.24 bcd	54.28 bcd
S_2F_3	16.01 a	36.81 b	47.02 b	54.49 b
S_3F_0	11.56 e	32.14 g	40.05 g	49.82 g
S_3F_1	13.24 cd	34.47 ef	44.22 ef	52.78 e
S_3F_2	14.04 bc	35.30 de	45.57 bcde	53.86 cd
S_3F_3	14.10 bc	36.13 bcd	46.17 bcd	53.99 bcd
LSD (0.05)	1.0398	1.0465	1.7152	0.6004
CV%	3.94	5.74	6.29	4.26

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

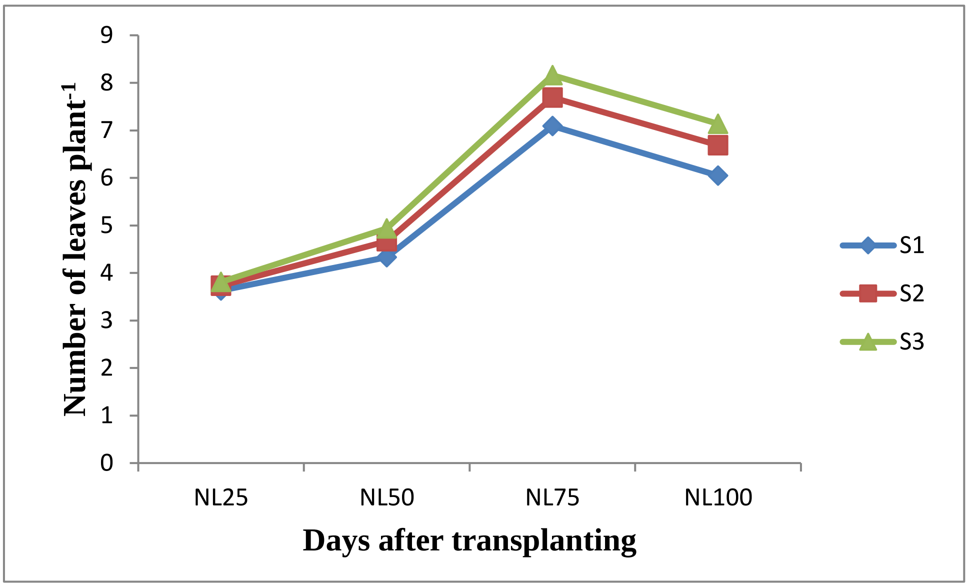
Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20 cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.2 Number of leaves plant $^{-1}$

Plant spacing in bunching onion showed a significant variation on number of leaves per plant at 25,50,75,100 DAT, under the present trial (Figure 4). Numerically leaf production was increased up to 75 DAT and there after decreased due to senescence. At 75 DAT, the highest number of leaves per plant (8.16) was recorded from S_3 which was statistically identical (7.69) to $S_{2,}$ while the lowest (7.09) was recorded from S_1. The highest number of leaves per plant (7.14) was recorded from S_3 treatment which was statistically followed by S_2 (6.69) treatment where as the lowest number of leaves per plant (6.05) was obtained from S_1 treatment at 100 DAT (Figure 4). Kumar *et al.* (1998) reported that the 20 cm x 20 cm spacing was the best with regard to number of leaves per plant. Kumar *et al*. (1998) and Jilani *et al*. (2009) also showed that higher leaf numbers per plant of onion were recorded in response to wider plant spacing.

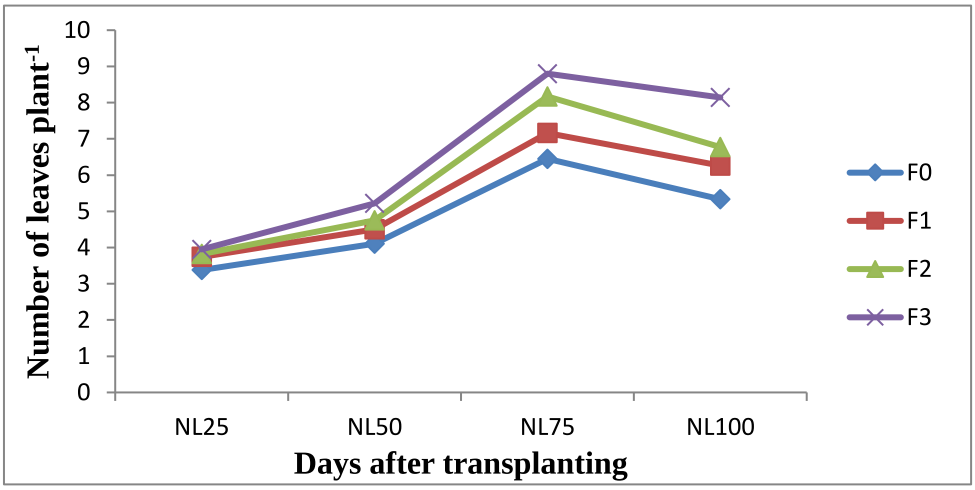
Number of leaves per plant was found to be significantly influenced by the application of different levels of fertilizers treatment at 25,50,75,100 DAT (Figure 5 and Appendix V). The number of leaves per plant was the maximum number of leaves (8.80) produced by F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment at 75 DAT when the minimum number of leaves (6.45) from F_0 (control) treatment at 75 DAT. Leaves of plant was increased up to 75 DAT and then decreased due to the plant senescence stages. The photosynthesis and other physiological process of plant depend on nitrogen and potassium. Number of leaves per plant is an important yield contributing factor of bunching onion. Optimum level of NPKS might have increase the availability of plant nutrients resulting in increased better performance of crop growth and ultimately produced a greater number of leaves per plant. Rizk (1991) found that the increasing levels of NPK increased the number of leaves. Nasiruddin *et al.* (1993) also reported that the number of leaves per plant increased due to application of K and S.

Combined effect of plant spacing and fertilizer was significantly impact by leaves per plant. At 75 DAT, the maximum number of leaves per plant 9.27 obtained from S_3F_3 (20cm×20cm which was statistically identical by S_2F_3 (20 cm x 15 cm with $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha)}$. On the other hand, the minimum leaves per plant 6.28 was recorded from S_1F_0 (Control with 20 cm x10 cm) treatment combination which was statistically identical to S_2F_0 (Table 4). From the results of the present study, it can be concluded that the treatment S_3F_3 produced better growing condition perhaps due to supply of adequate plant nutrients, resulting in the maximum number of leaves per plant. Consistent with the results of this study, Khan *et al*. (2002) also indicated that lower leaf number per plant of onion was recorded from the treatment interaction effects of control nitrogen level and narrow intra-row spacing.



Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20 cm

Figure 4. Effect of spacing on the number of leaves of bunching onion (*Allium fistulosum L.)*



F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$,$F_3$: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

Figure 5. Effect of different levels of fertilizer on the number of leaves bunching onion (*Allium fistulosum L.)*

Table 4. Combined effects of spacing and fertilizer on the number of leaves per plant of bunching onion (*Allium fistulosum L.*)

Treatment	Number of leaves at			
	25 DAT	50 DAT	75 DAT	100 DAT
S_1F_0	3.28	3.68 e	6.28 f	4.80 g
S_1F_1	3.63	4.40 cd	6.40 ef	5.71 ef
S_1F_2	3.78	4.54 bcd	7.62 cd	6.15 e
S_1F_3	3.83	4.68 bcd	8.07 bc	7.52 bc
S_2F_0	3.38	4.30 de	6.31 f	5.54 f
S_2F_1	3.77	4.53 bcd	7.32 cde	5.93 ef
S_2F_2	3.83	4.66 bcd	8.05 bc	7.26 cd
S_2F_3	3.92	5.19 ab	9.07 a	8.04 b
S_3F_0	3.47	4.37 cd	6.76 def	5.65 ef
S_3F_1	3.81	4.57 bcd	7.77 c	7.13 cd
S_3F_2	3.85	5.04 bc	8.83 ab	6.90 d
S_3F_3	4.1	5.78 a	9.27 a	8.85 a
LSD (0.05)	1.0072 NS	0.6729	0.9804	0.5979
CV%	11.07	8.44	7.9	5.42

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

Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.3 Plant base diameter

Plant base diameter of bunching onion showed non-significant effect due to different plant spacing (Table 5 and Appendix VI). The maximum plant base diameter (2.69cm) was obtained from S_3 (20cm×20cm) treatment and lowest plant base diameter (2.44cm) recorded from S_1 (20cm×10cm).

Plant base diameter was found non-significant effect due to application of different fertilizer treatment. The maximum (2.91cm) plant base diameter was obtained from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and lowest plant base diameter (2.10cm) obtained from F_0 (Control) treatment (Table 6).

Combined effect of plant spacing and fertilizer was also found non-significant effect on the plant base diameter. The maximum diameter (2.97cm) obtained from S_3F_3 (20cm×20cm with $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination. On the other hand, the minimum diameter (1.63cm) was recorded from S_1F_0 (Control with 20 cm x10 cm) treatment (Table 7).

4.4 Days required for flower bud initiation

Statistically variation was found among the different spacing treatment. First flower bud initiation was earlier in S_3 (20cm×20cm) treatment (61.67 days) than S_1 (20cm×10cm) treatment (63.82 days) (Table 5). Plant in wider spacing received maximum nutrients, so that first flower bud initiation occurs earlier. Umesh-Thapa (2004) found that 50% flowering occurred earlier in wider spaced plant.

Significant variation was found among the different levels of fertilizer treatment in respect of days required to first bud initiation (Appendix VI). The longest period (67.44 days) was required for first bud initiation in F_0 (Control) treatment followed by (63.33 days) F_1 treatment while shortest period (58.31 days) was recorded in F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment (Table 6). Ali *et al*. (2007) stated similar result by using nitrogen and potassium but phosphorus and sulphur at recommended doses.

The combined effect of plant spacing and different levels of fertilizer was found to be statistically significant on the days required to first bud initiation (Table 7 and Appendix VI). Minimum time (57 days) required for first flower bud initiation was found from the treatment combination of S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$). On the other hand, the maximum time (69.33 days) was required from the treatment combination of S_1F_0 (20cm ×10cm with control condition) which was followed by S_2F_0. (Table 7). This might be due to optimum level of fertilizers with wider spacing which influence C:N ratio.

Table 5. Effect of spacing on plant base diameter (cm), Days required for flower bud initiation and Dry matter content in leaves (%) of bunching onion *(Allium fistulosum L.)*

Treatment	Plant base diameter (cm)	Days required for flower bud initiation	Dry matter content (%)
S_1	2.44	63.82 a	9.226 c
S_2	2.66	62.58 b	9.542 b
S_3	2.69	61.67 c	10.098a
LSD (0.05)	0.7765 ^{NS}	0.629	0.2532
CV%	6.88	4.21	5.25

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm.

Table 6. Effect of different levels of fertilizer on plant base diameter (cm), Days required for flower bud initiation and Dry matter content in leaves (%) of bunching onion *(Allium fistulosum L.*)

Treatment	Plant base diameter (cm)	Days required for flower bud initiation	Dry matter content (%)
F_0	2.1	67.44 a	8.64d
F_1	2.63	63.33 b	9.39c
F_2	2.76	61.67 c	10.003b
F_3	2.9111	58.31 d	10.46a
LSD (0.05)	0.8966 ^{NS}	0.7263	0.2924
CV%	6.88	4.21	5.25

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

Here, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2:$N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3:$N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.5 Dry matter content in leaves

Dry matter content in leaves varied significantly due to plant spacing in bunching onion under the present trial (Table 5 and Appendix VI). The maximum (10.098%) dry matter content of foliage was obtained from S_3 (20 cm ×20 cm), while the minimum (9.226%) dry matter content of foliage was obtained from S_1 (20 cm x 10cm) which was statistically similar (9.542%) to S_2 (20 cm x15cm) (Table 3). This might be due to that lower competition between plants in the widest spacing, for that reason more vegetative growth occurred that enhance higher weight of dry leaves per plant. This result was supported by other scientists like Jan *et al*. (2003) and Tiwari *et al.* (2002). Mondal and Islam (1987) found that fresh and dry weights of leaves and bulbs were also decreased due to significantly increase in ratio of bulb length to bulb diameter which was significantly influence by spacing.

Different levels of fertilizer showed statistically significant differences on dry matter content in leaves of bunching onion (Table 6 and Appendix VIII). The maximum (10.5%) dry matter content of foliage was recorded from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) which was statistically similar (10.003%) to F_2 ($N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$) and the minimum (8.64 %) dry matter content of foliage was recorded from F_0 (control). With increasing level of fertilizer dry matter content of foliage also increased but the difference was not significant at highest level. Hedge (1988) mentioned that higher uptake of NPK, Ca and Mg in leaves produced higher dry matter.

Combined effect was also found significant due to plant spacing and different levels of fertilizers consideration of dry matter content of foliage under the present experiment (Table 7 and Appendix VIII). The maximum (10.89%) dry matter content of foliage was found from the treatment combination of S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}$ $PM_{3t/ha}$) and the minimum (8.09 %) dry matter content of foliage was recorded from S_1F_0 (20cm×10cm and control) treatment combination (Table 5).

Table 7. Combined effects of spacing and fertilizer on the plant base diameter (cm), Days required for flower bud initiation and Dry matter content in leaves (%) of bunching onion (*Allium fistulosum* L.)

Treatment	Plant base diameter(cm)	Days required for flower bud initiation	Dry matter content (%)
S_1F_0	1.63	69.33 a	8.09 f
S_1F_1	2.6	64.33 c	8.89 e
S_1F_2	2.7	62.33 de	9.83 cd
S_1F_3	2.83	59.27 g	10.093 bc
S_2F_0	2.3	67.00 b	8.4 ef
S_2F_1	2.63	63.00 d	9.49 d
S_2F_2	2.77	61.67 ef	9.89 bcd
S_2F_3	2.93	58.67 g	10.39ab
S_3F_0	2.37	66.00 b	9.42 d
S_3F_1	2.65	62.67 de	9.79 cd
S_3F_2	2.8	61.00 f	10.29 bc
S_3F_3	2.97	57.00 h	10.89a
LSD (0.05)	1.5530 ^{NS}	1.2579	0.5064
CV%	6.88	4.21	5.25

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

Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.6 Length of flowering stalk

Different plant spacing showed significant differences on length of flowering stalk of bunching onion plant. The highest flower stalk (43.92cm) was obtained from S_3 (20 cm x 20 cm) treatment which was statistically followed by S_2 (20cm× 15cm) and the lowest flower stalk (40.03cm) was obtained from S_1 (20cm×10cm) treatment. (Table 8). Wider spacing increased the quantity of flower stalks per plant (Nehra *et al.*,1988). Bhardwaj (1991) also found the same result.

Table 8. Effect of spacing on the length of flowering stalk (cm) and diameter of flowering stalk (cm) of bunching onion (*Allium fistulosum L.)*

Treatment	Length of flower stalk (cm)	Diameter of flower stalk (cm)
S_1	40.03 c	1.98
S_2	42.42 b	2.02
S_3	43.92a	2.18
LSD (0.05)	0.705	0.7793^{NS}
CV%	7.28	9.29

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm.

Length of flowering stalk was greatly influenced by the application of different levels of organic and inorganic fertilizer. Excessive growth of flowering stalk is not good for a seed production of bunching onion. The maximum flowering stalk (44.47cm) was obtained from F_3($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment which was followed by F_2 treatment and the minimum flowering stalk (39.95 cm) was noted from F_0 (Control). (Table 9).

Table 9. Effect of different levels of fertilizer on the length of flowering stalk (cm) and diameter of flowering stalk (cm) of bunching onion *(Allium fistulosum* L.)

Treatment	Length of flower stalk (cm)	Diameter of flower stalk (cm)
F_0	39.95 d	1.79
F_1	41.31 c	2.05
F_2	42.75 b	2.14
F_3	44.47 a	2.26
LSD (0.05)	0.8141	0.8998^{NS}
CV%	7.28	9.29

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2:$N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3:$N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

Combined effect of plant spacing and different levels of fertilizers was significantly affected on length of flowering stalk. The maximum length of flowering stalk (46.79cm) obtained from S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination which was statistically followed by S_3F_2 and S_2F_3 treatment combination. On the other hand, minimum length of flowering stalk (37.05 cm) was recorded from S_1F_0 (20cm×10cm and control) treatment combination. (Table 10).

Table 10. Combined effects of spacing and fertilizer on the length of flowering stalk (cm) and diameter of flowering stalk (cm) of bunching onion (*Allium fistulosum* L.)

Treatment	Length of flower stalk (cm)	Diameter of flower stalk (cm)
S_1F_0	37.05 f	1.64
S_1F_1	39.51 e	2.02
S_1F_2	41.58 cd	2.08
S_1F_3	41.98 cd	2.19
S_2F_0	40.72 de	1.69
S_2F_1	41.86 cd	2.05
S_2F_2	42.46 c	2.09
S_2F_3	44.62 b	2.22
S_3F_0	42.09 cd	2.06
S_3F_1	42.57 c	2.07
S_3F_2	44.22 b	2.24
S_3F_3	46.79 a	2.36
LSD (0.05)	1.4101	1.56^{NS}
CV%	7.28	9.29

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

Here,

S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.7 Diameter of flowering stalk

Diameter of flowering stalk was found statistically non-significant effect due to the application of different plant spacing treatment (Table 8). The maximum (2.18cm) flowering stalk diameter was obtained from S_3 (20cm×20cm) treatment and lowest flowering stalk diameter (1.98 cm) obtained from S_1 (20cm×10cm).

Plant base diameter was found statistically non-significant effect due to application of different fertilizer treatment (Table 9). The maximum (2.26cm) flowering stalk diameter was obtained from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and lowest flowering stalk diameter (1.79cm) obtained from F_0 (Control) treatment

Combined effect of plant spacing and fertilizer was not significantly impact by plant base diameter (Table 10). The maximum diameter (2.36cm) obtained from S_3F_3

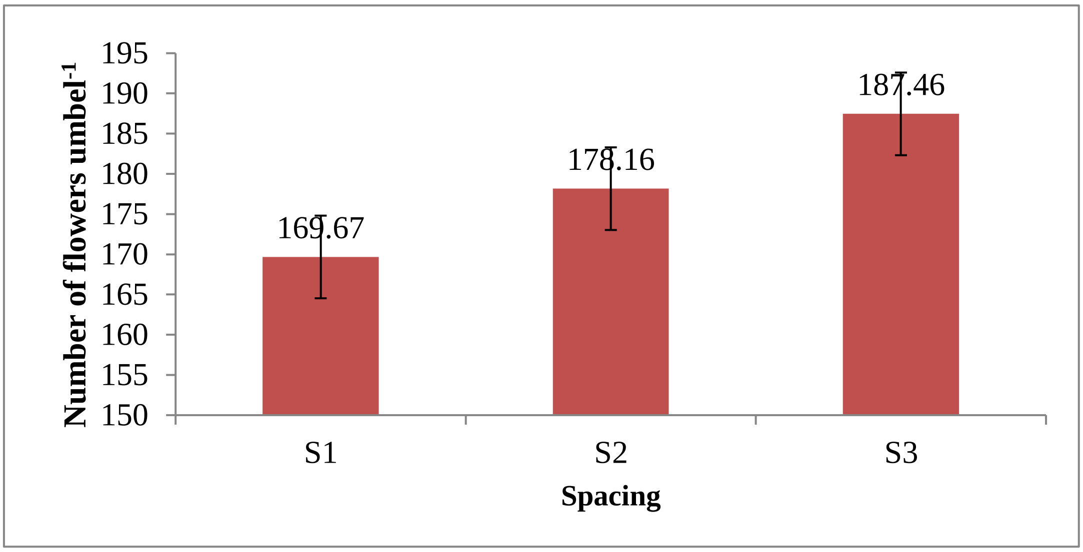
(20cm×20cm with $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination. On the other hand, the minimum diameter (1.64 cm) was recorded from S_1F_0 (Control with 20 cm x10 cm) treatment.

4.8 Number of flowers per umbel^{-1}

Number of flowers per umbel is one of the most important yield contributing characters in bunching onion seed production. Spacing had a significant variation on the number of flowers per umbel. The highest number of flowers per umbel (187.46) was recorded in S_3 (20 cm x 20 cm) and the lowest (169.67) in S_1 (20 cm x 10 cm) (Figure 6).

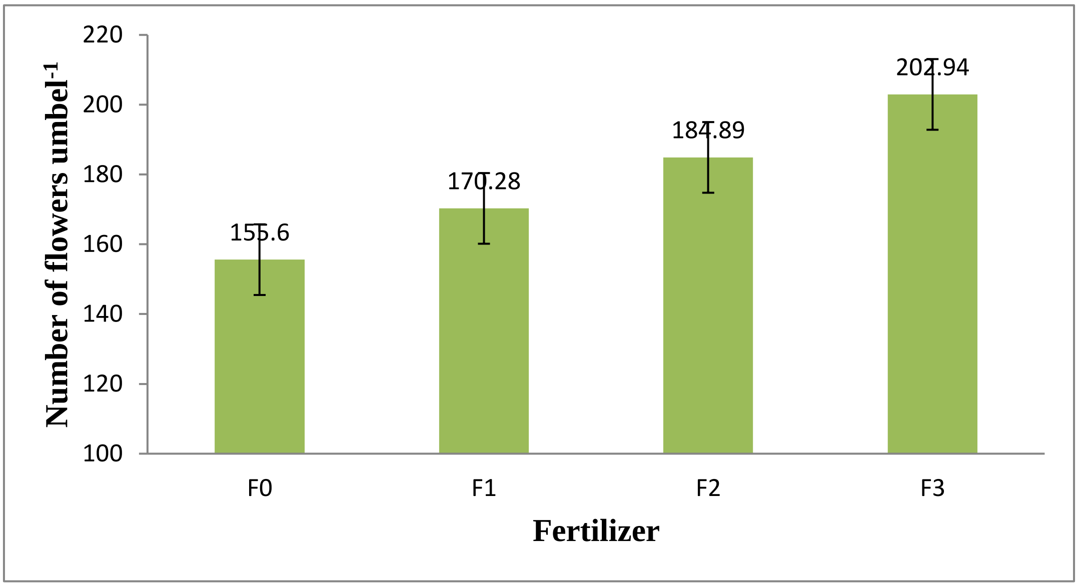
However, there was significant variation in the number of flowers per umbel due to the application of fertilizer. Numerically maximum number of flowers per umbel (202.94) was obtained from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and the minimum (155.60) was obtained in F_0 (control) treatment (Figure 7).

Combined effect of different spacing and different level of fertilizer was found significant variation on number of flowers per umbel (Table 11 and Appendix VII). The highest number of flowers per umbel (217.67) was obtained from S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment, while the minimum (146.17) from S_1F_0 (20cm×10cm and control) combination.



Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm

Figure 6. Effect of spacing on the number of flowers per umbel of bunching onion (*Allium fistulosum* L.)



F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3:$N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

Figure 7. Effect of different levels of fertilizer on the number of flowers per umbel of bunching onion (*Allium fistulosum* L.)

Table 11. Combined effects of spacing and fertilizer on the number of flowers per umbel of bunching onion (*Allium fistulosum* L.)

Treatment	Number of flowers /plant
S_1F_0	146.17 g
S_1F_1	164.67 f
S_1F_2	179.50 de
S_1F_3	188.33 cd
S_2F_0	158.30 f
S_2F_1	168.84 ef
S_2F_2	182.67 cd
S_2F_3	202.83 b
S_3F_0	162.34 f
S_3F_1	177.33 de
S_3F_2	192.50 bc
S_3F_3	217.67 a
LSD (0.05)	11.462
CV%	3.84

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

Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.9 Number of umbels per plant^{-1}

The number of umbels per plant was significantly depended on spacing. The maximum umbel per plant (2.87) was showed from S_3 (20 cm x 20 cm) treatment which was statistically identical to S_2 and the minimum umbel per plant (2.46) was obtained from S_1 (20 cm x 10 cm) treatment (Table 12).

The number of umbels per plant differed significantly with the application of different levels of organic and inorganic fertilizers (Appendix VII). It was observed that the highest number of umbels (3.52) was found in F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and the F_0 (control) treatment produced the lowest number of umbels (1.89). (Table 13). Shasha *et al.* (1976) stated similar result in presence of adequate moisture by using different levels of nitrogen and phosphorus and recommended doses of potassium and sulfur.

The variation among the different spacing with organic and inorganic nutrients in relation to the number of umbels per plant was found to be statiscally significant (Table 14 and Appendix VII). The highest number of umbels per plant (3.79) was observed from the treatment combination S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) while the lowest (1.67) was obtained from the treatment combination of S_1F_0 (20cm×10cm and control) .These results indicated that the different plant spacing when used with NPKS, Vermicompost and poultry manure combinedly supplied plant nutrients and provide better growing conditions which helped for getting proper vegetative growth as well as maximum number of umbels per plant.

Table 12. Effect of spacing on the number of umbels per plant and Umbel diameter (cm) of bunching onion (*Allium fistulosum* L.)

Treatment	Number of umbels /plant	Umbel diameter (cm)
S_1	2.46 b	5.92 b
S_2	2.81 a	6.07 b
S_3	2.87 a	6.46 a
LSD (0.05)	0.1753	0.2458
CV%	7.45	4.7

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20 cm.

Table 13. Effect of different levels of fertilizer on the number of umbels per plant and Umbel diameter (cm) of bunching onion (*Allium fistulosum* L.)

Treatment	Number of umbel /plant	Umbel diameter (cm)
F_0	1.89 d	5.50 d
F_1	2.35 c	5.94 c
F_2	3.09 b	6.34 b
F_3	3.52 a	6.81 a
LSD (0.05)	0.2024	0.2838
CV%	7.45	4.7

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2:$N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3:$N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

Table 14. Combined effects of spacing and fertilizer on the number of umbels per plant and Umbel diameter (cm) of bunching onion (*Allium fistulosum L.)*

Treatment	Number of umbel /plant	Umbel diameter (cm)
S_1F_0	1.67 h	5.17 f
S_1F_1	2.16 efg	5.78 de
S_1F_2	2.86 d	6.19 bcd
S_1F_3	3.17 cd	6.53 b
S_2F_0	1.93 gh	5.34 ef
S_2F_1	2.38 ef	6.01 cd
S_2F_2	3.33 bc	6.28 bc
S_2F_3	3.59 ab	6.65 b
S_3F_0	2.08 fg	5.98 cd
S_3F_1	2.50 e	6.04 cd
S_3F_2	3.09 cd	6.56 b
S_3F_3	3.79 a	7.24 a
LSD (0.05)	0.3506	0.4916
CV%	7.45	4.7

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

Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.10 Umbel Diameter

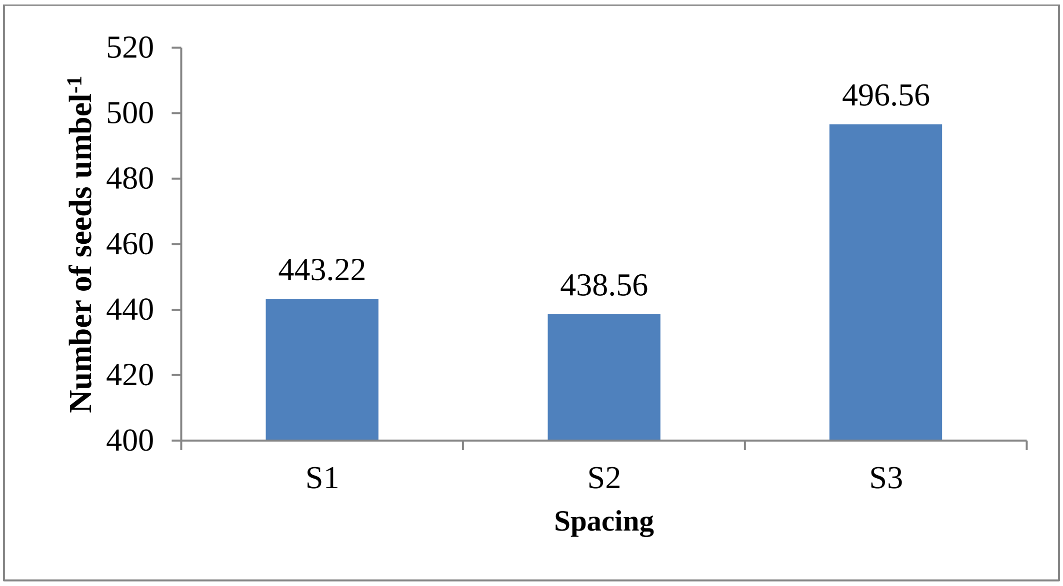
The result showed significant differences on umbel diameter of bunching onion with the different spacing treatments (Table 12 and Appendix VII). The maximum umbel per plant (6.46 cm) was obtained from S_3 (20 cm x 20 cm) treatment and the minimum umbel diameter (5.92 cm) was obtained from S_1 treatment which was identical to S_2 treatment.

The result showed significant differences on umbel diameter of bunching onion with the different levels of fertilizer application (Table 13 and Appendix VII).The maximum umbel diameter (6.81cm) was noted from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and the minimum umbel per plant (5.50 cm) was noted from F_0 (Control). It might be due to the fact of higher doses of nitrogen in combination with optimum better growth and development of plants resulted high umbel diameter in F_3 treatment. This result aggresses with the finding of Sing *et al.* (1965).

Combined effect of plant spacing and different levels of fertilizer application was significantly affected on umbel diameter of bunching onion (Table 14 and Appendix VII). The maximum umbel diameter (7.24 cm) noted from S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination which was followed by S_1F_3, S_2F_3 and S_3F_2 treatments combination. On the other hand, minimum umbel diameter (5.17 cm) was recorded from S_1F_0 (20cm×10cm and control) treatment combination.

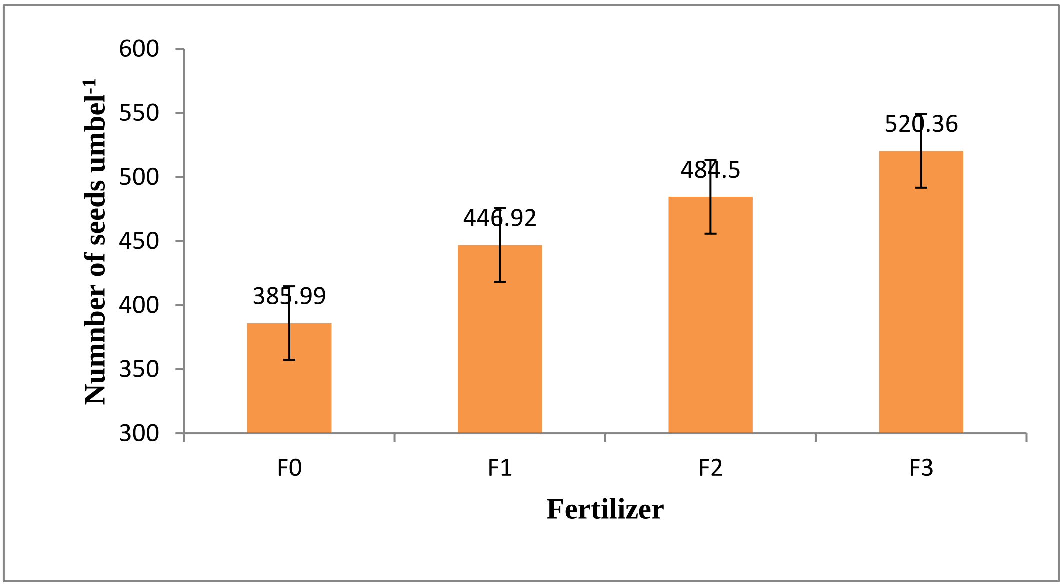
4.11 Number of seeds umbel^{-1}

The result showed has pragmatic impact on the on seed per umbel of bunching onion with the different plant spacing treatment. The maximum seed per umbel (496.56) was obtained from S_3 (20 cm x 20 cm) treatment and the minimum seed per umbel (443.22) was obtained from S_1 (20cm×10 cm) treatment, which was statistically identical to S_2 (20cm× 15 cm) (Figure 8).



Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm

Figure 8. Effect of spacing on the number of seeds per umbel of bunching onion (*Allium fistulosum* L.)



F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3:$N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

Figure 9. Effect of different levels of fertilizer on the number of seeds per umbel of bunching onion (*Allium fistulosum* L.)

Table 15. Combined effects of spacing and fertilizer on the number of seeds per umbel of bunching onion (*Allium fistulosum* L.)

Treatment	Number of seeds/umbel
S_1F_0	345.80 f
S_1F_1	443.07 cd
S_1F_2	460.67 c
S_1F_3	523.33 b
S_2F_0	394.33 e
S_2F_1	446.40 cd
S_2F_2	468.17 c
S_2F_3	445.33 cd
S_3F_0	417.83 de
S_3F_1	451.30 cd
S_3F_2	524.67 b
S_3F_3	592.42 a
LSD (0.05)	41.145
CV%	5.16

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

Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

The result showed significant differences on seed per umbel of bunching onion with the different fertilizer application (Appendix VII). The maximum seed per umbel (520.36) was obtained from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and the minimum seed per umbel (385.99) was noted from F_0 (Control). (Figure 9). Mozumdar et al. (2007) stated that application of N, K and S significantly increased yield and yield attributes.

Combined effect of plant spacing and different levels of organic and inorganic fertilizers was significantly affected by seeds per umbel of bunching onion (Table 15). The maximum seeds per umbel (592.42) obtained from S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination which followed by S_3F_2 and S_1F_3 treatment combination. On the other hand, minimum seed per umbel (345.80) was recorded from S_1F_0 (20cm×10cm and control) treatment combination.

The results revealed that number of seeds per umbel increased with the application of organic and inorganic sources of plant nutrients with wider spacing, which lead the plant growth favorably and production of more seeds per umbel. Mozumder *et al.*

(2007), stated that application of N, P, K and S significantly increase yield and yield attributes.

4.12 1000 seed weight (g)

Thousand seed weight of bunching onion was found significantly differ due to spacing (Table 16). The highest thousand seed weight (3.64 g) was obtained from S_3 (20 cm x 20 cm) and the minimum (3.32 g) from S_1 (20 cm x 10 cm) treatment.

There was significant variation in the thousand seed weight of bunching onion due to the application of different levels of organic and inorganic fertilizer. The maximum thousand seed weight (4.08g) was obtained from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and the minimum (2.78g) from F_0 (Control) (Table 17). Tiwari *et al.* (2002) stated that 1000 seed weight was affected significantly by NPKS at recommended doses.

Combined effects of different spacing and application of organic and inorganic fertilizer had significant influenced on thousand seed weight (Table 18). The highest thousand seed weight (4.28g) was obtained from S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination followed by S_2F_3 treatment combination while the lowest (2.66 g) was found from S_1F_0 (20cm×10cm and control) treatment combination. Increased of 1000 seeds weight might be due to the fact that combined application of vermicompost with NPKS fertilizers helped quick availability of plant nutrient to better synthesis of carbohydrates and their translocation to the seed.

4.13 Seed yield plant^{-1} (g)

Seed yield per plant differed significantly due to the application of different levels of plant spacing (Table 16). Plant spacing has significant influence on the seed yield per plant. The highest seed yield per plant (3.61g) was obtained from S_3 (20 cm x 20 cm) treatment and followed by S_2 (20cm× 15 cm). and the lowest seed yield per plant (2.13 g) was noted from S_1 (20 cm x 10 cm) treatment.

Table 16. Effect of spacing on the on the 1000 seed weight (gm), seed yield plant^{-1}(gm), seed yield plot^{-1} (gm) of bunching onion (*Allium fistulosum* L.)

Treatment	**1000 seed wt (g)**	**Seed yield/plant (g)**	**Seed yield/plot (g)**
S_1	3.32c	2.13 c	153.36 a
S_2	3.42b	2.85 b	133.56 b
S_3	3.64 a	3.61 a	129.60 c
LSD (0.05)	0.0801	0.2292^{NS}	1.2237
CV%	2.79	5.24	6.23

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm.

The effect of different levels of organic and inorganic fertilizer on seed yield per plant was found to be statistically significantly influenced (Table 17). The maximum seed yield per plant (3.29 g) was obtained from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and the minimum seed yield per plant (2.36 g) was noted from F_0 (Control) treatment. The reason for higher seed yield per plant due to increase of photosynthesis rate and translocation of food materials to seed. Howladar *et al.* (2015) stated the similar result but present experiment showed the lowest seed yield per plant than Howlader *et al*. (2015) who used of nitrogen and sulphur at recommended doses.

Combined effect of plant spacing and fertilizers was significantly impacted on seed yield per plant (Table 18). The maximum seed yield per plant (4.11g) obtained from S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination which was followed by S_3F_2 treatment combination. On the other hand, minimum seed yield per plant (1.72g) was recorded from S_1F_0 (20cm×10cm and control) treatment combination. The possible reason is due to wider spacing with combined application of organic and inorganic fertilizer, which lead the plant growth favorably and results the production of more seeds per plant.

Table 17. Effect of different levels of fertilizer on the 1000 seed weight (gm), seed yield plant^{-1} (gm), seed yield plot^{-1}(gm) of bunching onion (*Allium fistulosum* L.)

Treatment	1000 seed wt (g)	Seed yield/plant (g)	Seed yield/plot (g)
F_0	2.78 d	2.36 c	113.87 d
F_1	3.28 c	2.79 b	136.44 c
F_2	3.68 b	2.99 b	146.36 b
F_3	4.08 a	3.29 a	157.48 a
LSD (0.05)	0.0925	0.2646	1.4130
CV%	2.79	5.24	6.23

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

Here, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2:$N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3:$N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/h}$

Table 18. Combined effect of spacing and fertilizer on the 1000 seed weight (gm), seed yield plant^{-1}(gm), seed yield plot^{-1}(gm) of bunching onion (*Allium fistulosum* L.)

Treatment	1000 seed wt (g)	Seed yield/plant (g)	Seed yield/plot (g)
S_1F_0	2.66	1.72 i	123.84 ef
S_1F_1	3.09	2.04 hi	146.88 c
S_1F_2	3.58	2.24 gh	161.28 b
S_1F_3	3.96	2.52 efg	181.44 a
S_2F_0	2.72	2.37 fgh	113.76 i
S_2F_1	3.31	2.82 def	135.36 g
S_2F_2	3.62	2.96 de	142.08 e
S_2F_3	4.01	3.26 cd	143.04 d
S_3F_0	2.97	2.99 d	107.64 k
S_3F_1	3.45	3.53 bc	127.08 j
S_3F_2	3.84	3.77 ab	135.72 h
S_3F_3	4.28	4.11 a	147.96 fg
LSD (0.05)	0.1602	0.4583	2.4474
CV%	2.79	5.24	6.23

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

Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.14 Seed yield plot^{-1} (g)

The result showed significant differences on seed yield per plot of bunching onion with the different spacing treatment (Table 16). The maximum seed yield per plot

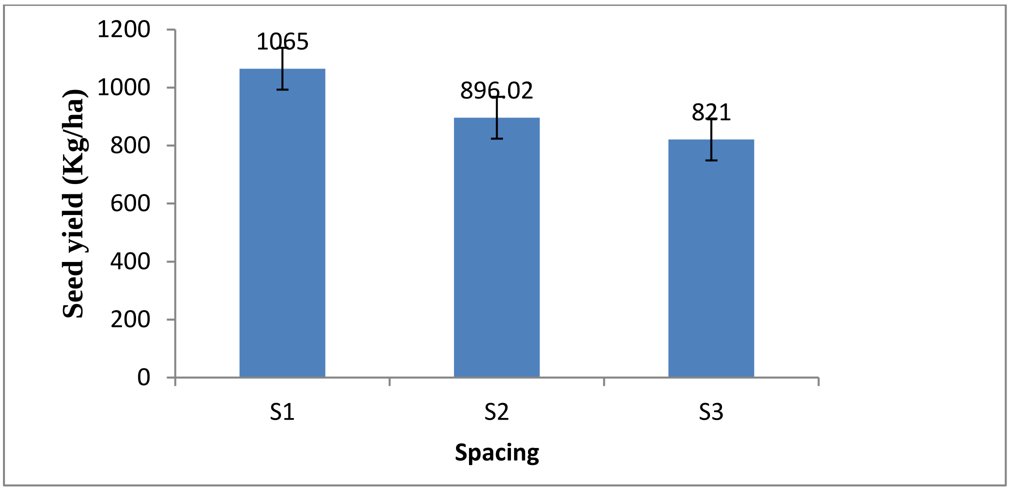
(153.36 g) was obtained from S_1 (20 cm x 10 cm) treatment and the minimum seed yield per plot (129.6 g) was noted from S_3 (20 cm x 20 cm) treatment.

The seed yield of bunching onion per plot was greatly influenced due to different levels of organic and inorganic fertilizers (Table 17). The result showed significant differences on seed yield per plot with the different doses of fertilizer application. The maximum seed yield per plot (157.48 g) was obtained from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and the minimum seed yield per plot (113.87 g) was noted from F_0 (Control) treatment. Ali *et al.* (2007) reported similar result. They obtained higher seeded fruits, number of seeded fruits /umbels, weight of seeds/umbel, seed yield, gemination percentage with the application of different levels of nitrogen and potassium.

Combined effect of plant spacing and different fertilizer combination on the seed yield per plot was highly significant. The maximum seed yield per plot (181.44 g) obtained from S_1F_3 (20cm×10cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination followed by S_1F_2 (20cm×10cm with $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$) treatment combination. On the other hand, minimum seed yield per plot (107.64 g) was recorded from S_3F_0 (20cm×20cm with control) treatment combination (Table 18).

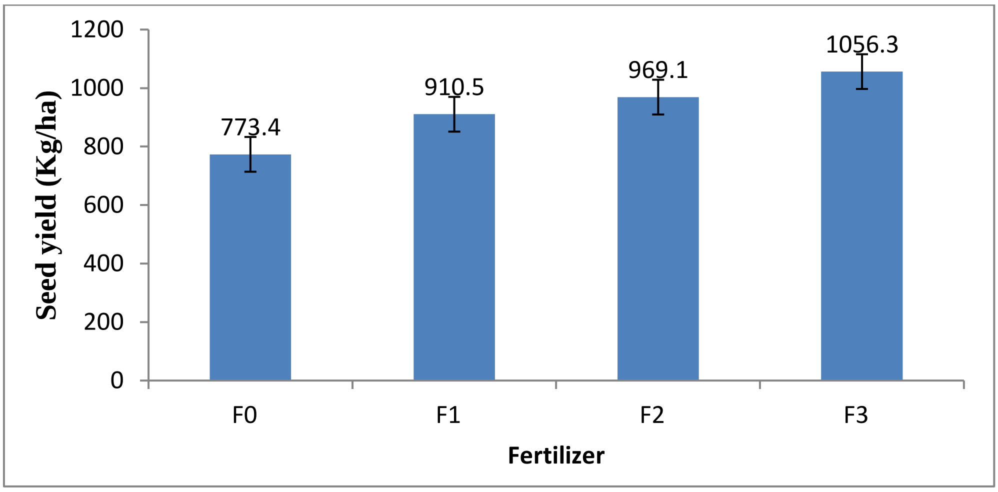
4.15 Seed yield (kg ha^{-1})

The result showed significant differences on seed yield per hectare of bunching onion with the different plant spacing (Figure 10). The highest seed yield per hectare (1065 kg) was obtained from S_1 (20 cm x 10 cm) treatment and the minimum seed yield per hectare (821 kg) was noted from S_3 (20 cm x 20 cm) treatment. Different levels of organic and inorganic fertilizers application showed significant differences on seed yield of bunching onion per hectare (Figure 11). The maximum seed yield per hectare (1056.3 kg) was obtained from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and the minimum seed yield per hectare (773.4 kg) was noted from F_0 (Control) treatment. Optimum levels of fertilizer application had increased seed yield per hectare.



Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm

Figure 10. Effect of spacing on seed yield ha^{-1} (kg) of bunching onion (*Allium fistulosum* L.)



F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3:$N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

Figure 11. Effect of different levels of fertilizer on seed yield ha^{-1} (kg) of bunching onion (*Allium fistulosum* L.)

Combined effect of plant spacing and different levels of fertilizer is greatly impact on seed yield per hectare (Table 19). The highest seed yield per hectare (1260.0 kg) obtained from S_1F_3 (20cm×10cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination. On the other hand, lowest seed yield per hectare (700.2 kg) was recorded from S_3F_0 (20cm×20cm with control) treatment combination.

Table 19. Combined effect of spacing and fertilizer on the seed yield ha^{-1}(kg) of bunching onion (*Allium fistulosum* L.)

Treatment	Seed yield (kg/ha)
S_1F_0	860.00 h
S_1F_1	1020.02 c
S_1F_2	1120.00 b
S_1F_3	1260.01 a
S_2F_0	760.00 j
S_2F_1	898.90 g
S_2F_2	926.70 e
S_2F_3	998.50 d
S_3F_0	700.20 k
S_3F_1	812.70 i
S_3F_2	860.50 h
S_3F_3	910.50 f
LSD (0.05)	10.556
CV%	6.23

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

Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.16 Germination (%)

In case of germination percentage, the effect of spacing was found non-significant. The highest (85.73) seed germination percentage was found in S_3 (20 cm x 20 cm) treatment and lowest (84.29) in S_1 (20 cm x 10 cm) treatment (Table 20).

Table 20. Effect of spacing on the germination percentage of seed of bunching onion (*Allium fistulosum* L.)

Treatment	**Seed germination (%)**
S_1	84.29
S_2	84.12
S_3	85.73
LSD (0.05)	3.8406 ^{NS}
CV%	5.49

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm.

The effect of different levels of fertilizer was found non-significant. The highest (87.22) seed germination percentage was observed in F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and lowest (83.24) in F_0 (Control) treatment (Table 21).

Table 21. Effect of different levels of fertilizer on the germination percentage of seed of bunching onion (*Allium fistulosum* L.)

Treatment	**Seed germination (%)**
F_0	83.24
F_1	83.22
F_2	85.16
F_3	87.22
LSD (0.05)	4.4348 ^{NS}
CV%	5.49

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2:$N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3:$N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

Combined effect of plant spacing and different levels of fertilizer was found non-significant. Highest seed germination percentage (88.33) was carried out in S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination and lowest (83.00) in S_1F_0 (20cm×10cm and control) treatment combination (Table 22).

Table 22. Combined effect of spacing and fertilizer on the germination percentage of seed of bunching onion (*Allium fistulosum* L.)

Treatment	**Seed germination (%)**
S_1F_0	83.00
S_1F_1	84.00
S_1F_2	84.83
S_1F_3	85.33
S_2F_0	83.16
S_2F_1	81.33
S_2F_2	84.00
S_2F_3	88.00
S_3F_0	83.58
S_3F_1	84.33
S_3F_2	86.67
S_3F_3	88.33
LSD (0.05)	7.6813 ^{NS}
CV%	5.49

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

Here, S_1: 20cm×10cm, S_2: 20cm×15cm, S_3: 20cm×20cm, F_0: Control, F_1: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2: $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$, F_3: $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$

4.17 Economic analysis

Input cost for land preparation, bunching onion seed cost, organic manures, fertilizers pesticides, irrigation and manpower required for all the operations from sowing to harvesting of bunching onion seed were recorded for unit plot and converted into cost per hectare. Price of bunching onion seed was considered as per market rate.

4.18 Gross return

The combination of spacing and different levels of fertilizer showed different gross return. The highest gross return (1260000Tk.) was obtained from S_1F_3 land the second highest gross return (1120000 Tk.) was found from S_1F_2. The lowest gross return (700200 Tk.) was obtained from the treatment combination of S_3F_0 (Table 23).

4.19 Net return

The combination of spacing and different levels of fertilizer showed different net return. The highest net return (699991.4 Tk.) was obtained in S_1F_3 and the second highest net return (585803.8 Tk.) was found in S_1F_2.The lowest net return (258214.25Tk.) was found in S_3F_0 (Table 23).

4.20 Benefit cost ratio

The combination of spacing and different levels of fertilizer showed different benefit cost ratio. The highest benefit cost ratio (2.26) was obtained in S_1F_3 and the second highest benefit cost ratio (2.10) was found in S_1F_2. The lowest benefit cost ratio (1.56) was obtained in the treatment combination of S_3F_0 (Table 23). From Economic point of view, it was apparent from the above results that the combination of S_1F_3 treatment combination was more profitable than rest of the combination.

Table 23. Cost and return of bunching onion (*Allium fistulosum* L.) influenced by spacing and fertilizer

Treatment Combinations	Cost of Production (TK/ha)	Seed yield (Kg/ha)	Gross return (Tk/ha)	Net return (Tk/ha)	Benefit cost ratio
S_1F_0	490296.3	860.0	860000	369703.7	1.74
S_1F_1	567901.2	1020.0	1020000	452098.8	1.80
S_1F_2	534196.2	1120.0	1120000	585803.8	2.10
S_1F_3	560008.6	1260.0	1260000	699991.4	2.26
S_2F_0	456141.0	760.0	760000	303859.0	1.65
S_2F_1	543745.95	898.9	898900	355154.05	1.69
S_2F_2	510041.0	926.7	926700	416659.0	1.81
S_2F_3	535853.3	998.5	998500	462646.7	1.86
S_3F_0	441985.8	700.2	700200	258214.25	1.56
S_3F_1	509590.7	812.7	812700	303109.35	1.60
S_3F_2	485885.7	860.5	860500	374614.35	1.77
S_3F_3	511698.1	910.5	910500	398801.9	1.82

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

*Sale of marketable seed @1000Tk/kg

*Net income = Gross return - Total cost of production

*Gross return = marketable yield × Tk/kg

*BCR= Gross return ÷Cost of production

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted in the field of Sher-e - Bangla Agricultural university during 2021 to find out the effects of growth and seed yield of bunching onion influence by plant density and different levels of fertilizer. The experiment consisted of three levels of spacing (viz. S_1 = 20cm×10cm, S_2 = 20cm×15cm and S_3 =20cm×20cm) and four levels of fertilizer (viz. F_0 = No application (control), F_1 = $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}V_{6t/ha}$, F_2 = $N_{57.5kg}P_{66kg}K_{45kg}S_{10kg}PM_{6t/ha}$ and F_3= $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$). The two-factor experiment was carried out in Randomized Complete Block Design (RCBD) with three replications. There were 12 treatment combinations in this study. A unit plot was 1.2 m×1.2 m and the treatments were distributed randomly in each block. Ten plants were randomly selected from middle portion avoiding border effect for data collection. Data were recorded on plant height, number of leaves per plant, plant base diameter, Days required for flower bud initiation, dry matter content in leaves, length of flower stem, diameter of flower stem, umbel diameter, number of umbels per plant, number of flowers per plant, number of seeds per umbel, seed yield per plant, seed yield per plot, seed yield per hectare, weight of 1000 seeds and percent seed germination. Data on growth and yield parameters were recorded and analyzed statistically. The differences were evaluated by Duncan's Multiple Range Test (DMRT). The mean separation was done by LSD test taking the probability level of 5% as the maximum unit of significance.

In case of spacing, the highest plant height (54.35 cm) and the lowest (52.61 cm) plant height were observed from S_1 (20cm×10cm) treatment and S_3 (20cm×20cm) treatment, respectively at 100 DAT. In case of fertilizer dose, the highest plant height (54.81cm) and lowest (51.66cm) was shown by F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and F_0 (control) treatment, respectively at 100 DAT. Also, the maximum plant height (55.95 cm) and the minimum (49.82 cm) were obtained from S_1F_3 (20cm×10cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination and S_3F_0 (20cm×20cm and control) treatment combination, respectively at 100 DAT.

The maximum leaves number per plant (8.16) and the minimum (7.69) were obtained from S_3 (20cm×20cm) treatment and S_1 (20cm×10cm) treatment, respectively at 75 DAT. The maximum leaves number per plant (8.80) and the minimum (6.45) was obtained from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and F_0 (control) treatment, respectively at 75 DAT. Also, the maximum leaves number per plant (9.27) and the minimum (6.28) was obtained from S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and S_1F_0 (20cm×10cm and control) treatment combination, respectively at 75 DAT. Leaves of plant was increased up to 75 DAT and then decreased due to the plant senescence stages.

The minimum time for flower bud initiation (61.67 days) and the maximum (63.82 days) were obtained from the S_3 (20cm×20cm) treatment and S_1 (20cm×10cm) treatment, respectively.The minimum time for flower bud initiation (58.31 days) and the maximum (67.44 days) were obtained from the F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and F_0 (control) treatment, respectively. The minimum time for flower bud initiation (57 days) and the maximum (69.33 days) were obtained from the S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination and S_1F_0 (20cm×10cm and control) treatment combination, respectively. The highest dry matter content in leaves (10.098) and lowest (9.226) was obtained from the S_3 (20cm×20cm) treatment and S_1 (20cm×10cm) treatment, respectively. The highest dry matter content (10.46) and lowest (8.64) was obtained from the F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and F_0 (control) treatment, respectively. Also, the maximum dry matter content in leaves (10.89) and minimum (8.09) were obtained from the S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination and S_1F_0 (20cm×10cm and control) treatment combination, respectively.

The highest length of flower stem (43.92cm) and diameter of flower stem (2.18 cm) were obtained from the S_3 (20cm×20cm) treatment. The lowest length of flower stem (40.03cm) and diameter (1.98 cm) were obtained from the S_1 (20cm×10cm) treatment. The highest length of flower stem (44.47cm) and diameter (2.26cm) were obtained from the F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment. The lowest length of flower stem (39.95 cm) and diameter (1.79 cm) were obtained from the F_0 (control) treatment. The highest length of flower stem (46.79 cm) and diameter (2.36

cm) were obtained from the S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination. The lowest length of flower stem (37.05 cm) and diameter (1.64 cm) were obtained from the S_1F_0 (20cm×10cm and control) treatment combination.

The maximum umbel diameter (6.46 cm) and minimum (5.92 cm) were obtained from S_3 (20cm×20cm) treatment and S_1 (20cm×10cm) treatment, respectively. The maximum umbel diameter (6.81 cm) and the minimum (5.50 cm) was obtained from F_3($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and F_0 (control) treatment, respectively. Also, the maximum umbel diameter (7.24 cm) and the minimum (5.17 cm) was obtained from S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and S_1F_0 (20cm×10cm and control) treatment combination, respectively.

The highest number of umbels (2.87) and flower (187.46) per plant were obtained from the S_3 (20cm×20cm) treatment and the lowest number of umbels (2.46) and flower (169.67) per plant were obtained from the S_1 (20cm×10cm) treatment. The highest number of umbels (3.52) and flower (202.94) per plant were obtained from the F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and the lowest number of umbels (1.89) and flower (155.60) per plant were obtained from the F_0 (control) treatment. Also, the highest number of umbels (3.79) and flower (217.67) per plant were obtained from the S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination and the lowest number of umbels (1.67) and flower (146.17) per plant were obtained from the S_1F_0 (20cm×10cm and control) treatment combination, respectively.

The highest number of seeds per umbel (496.56) and lowest (443.22) was obtained from the S_3 (20cm×20cm) treatment and S_1 (20cm×10cm) treatment, respectively. The highest number of seeds per umbel (520.36) and lowest (385.99) was obtained from the F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and F_0 (control) treatment, respectively. Also, the maximum number of seeds per umbel (592.42) and minimum (345.80) were obtained from the S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination and S_1F_0 (20cm×10cm and control) treatment combination, respectively.

The maximum (3.64 g) and minimum (3.32 g) 1000 seeds weight were found from

S_3 (20cm×20cm) treatment and S_1 (20cm×10cm) treatment, respectively. The maximum (4.08 g) and minimum (2.78 g) 1000 seeds weight were found from F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}$ $PM_{3t/ha}$) treatment and F_0 (control) treatment, respectively. Also, the maximum (4.28 g) and minimum (2.66 g) 1000 seeds weight were found from the S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination and S_1F_0 (20cm×10cm and control) treatment combination, respectively.

The highest seed yield (1065.0kg/ha) and lowest (821.0 kg/ha) was obtained from the S_1 (20cm×10cm) and S_3 (20cm×20cm) treatment, respectively. The highest seed yield (1056.3kg/ha) and lowest (773.4kg/ha) was obtained from the F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and F_0 (control) treatment, respectively. Also, the highest seed yield (1260.0 kg/ha) and lowest (700.2kg/ha) was obtained from the S_1F_3 (20cm×10cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination and S_3F_0 (20cm×20cm and control) treatment combination, respectively.

The highest germination percentage of bunching onion seed (85.73) and lowest (84.29) was found from S_3 (20cm×20cm) treatment and S_1 (20cm×10cm) treatment, respectively. The highest germination percentage of bunching onion seed (87.22) and lowest (83.24) was obtained from the F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment and F_0 (control) treatment, respectively. Also, the highest germination percentage of bunching onion seed (88.33) and lowest (83.00) was found from the S_3F_3 (20cm×20cm and $N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$) treatment combination and S_1F_0 (20cm×10cm and control) treatment combination, respectively.

Conclusion and recommendation

In considering the above results of this experiment, further studies in the following conclusion and recommendation can be drawn:

* In this experiment plant spacing S_1 (20cm×10cm) treatment gave highest seed yield (1065.0 kg/ha) per hectare of bunching onion.

* Combination of inorganic ($N_{115kg}P_{132kg}K_{90kg}S_{20kg/ha}$) and organic ($V_{3t/ha}$ + $PM_{3t/ha}$) treated plants gave highest growth and seed yield (1056.3 kg /ha) of bunching onion.

* However, from the present study it may be concluded that, the most suitable combination for a higher seed yield of bunching onion was S_1 (20cm×10cm) with F_3 ($N_{115kg}P_{132kg}K_{90kg}S_{20kg}V_{3t}PM_{3t/ha}$).

* From the economic point of view, the highest benefit cost ratio (2.26) was more profitable for bunching onion seed production.

* The study was conducted under AEZ NO 28. So, such type of trail may be studied in different agrological zones of Bangladesh for final recommendation.

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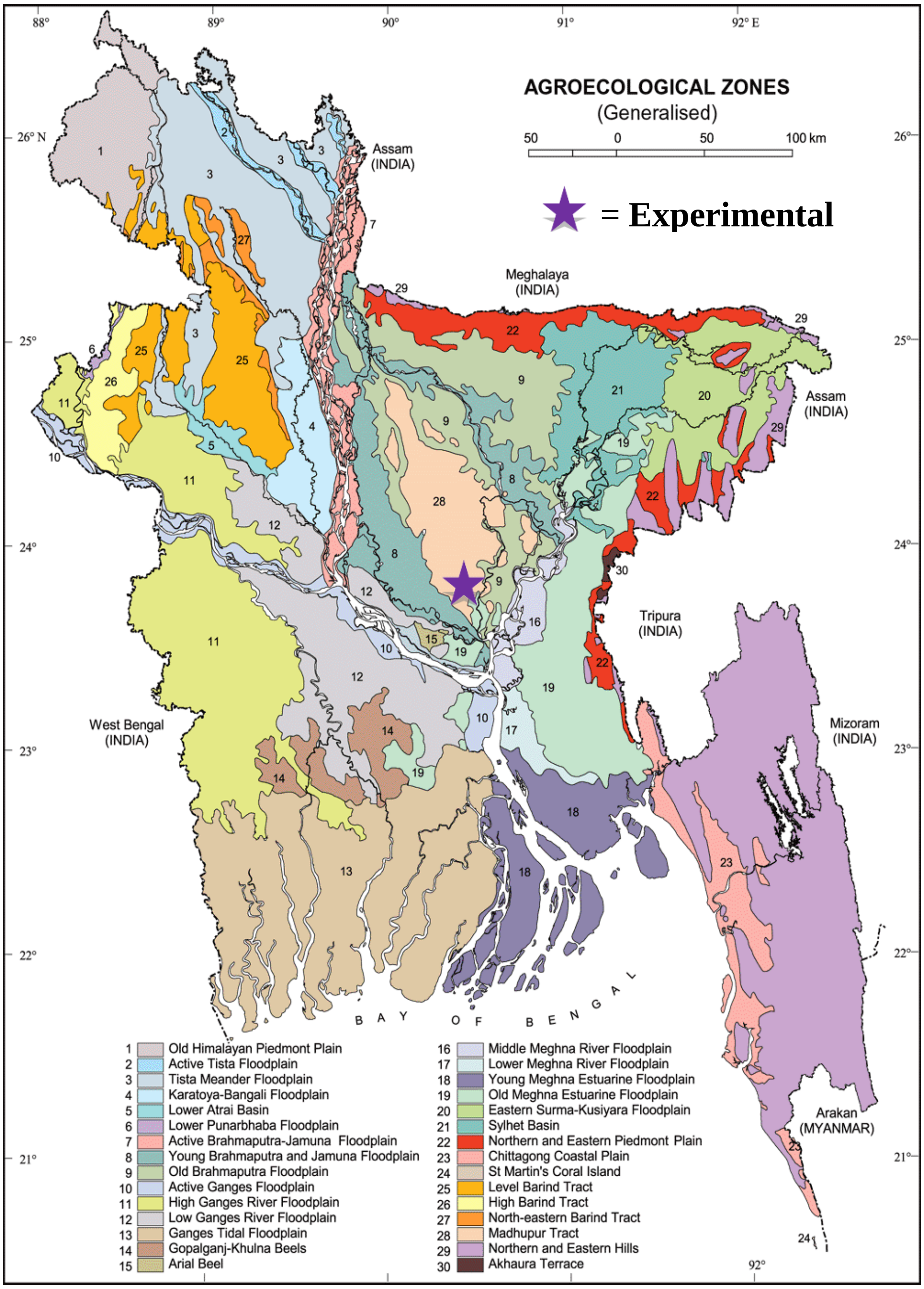
APPENDICES

Appendix I. Experimental location on the map of Agro-ecological Zones of Bangladesh



Appendix II. Characteristics of soil of experimental field

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Sher-e-Bangla Agricultural University Research Farm, Dhaka
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Deep Red Brown Terrace Soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimentalsite (0 - 15 cm depth)

Physical characteristics	
Constituents	**Percent**
Sand	26
Silt	45
Clay	29
Textural class	Silty clay
Chemical characteristics	
Soil characters	**Value**
pH	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total nitrogen (%)	0.05
Available P (ppm)	20.54
Exchangeable K (me/100 g soil)	0.10

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

Appendix III. Monthly meteorological information during the period from November, 2020 to April, 2021

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2020	November	28.9	11.2	58	46
	December	25.00	9.5	65.34	0
2021	January	30.4	15.6	68.4	50
	February	32.30	21.80	74.3	75
	March	33.9	13.6	55.29	102

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance of the data on plant height (cm) after (25DAT, 50 DAT, 75 DAT and 100 DAT) of bunching onion as influenced by combined effect of Spacing and different levels of fertilizer

Source of variation	Degree of freedom	Mean square Value			
		Plant height (cm)			
		25DAT	50DAT	75DAT	100DAT
Replication	2	1.2215	0.489	0.6976	0.0371
Spacing\(A)	3	5.6300*	7.0137**	17.1003**	9.1483**
Fertilizer (B)	2	15.4767**	25.2209**	45.4607**	16.6954**
Interaction (AxB)	6	0.9309**	0.6421**	2.9283**	1.2978**
Error	22	0.3043	0.3762	1.0667	0.1351

Appendix V. Analysis of variance of the data on number of leaves plant^{-1} after (25DAT, 50 DAT, 75 DAT and 100 DAT) of bunching onion as influenced by combined effect of Spacing and different levels of fertilizer.

Source of variation	Degree of freedom	Mean Square Value			
		Number of leaves			
		25 DAT	50 DAT	75 DAT	100 DAT
Replication	2	2.4181	0.22484	0.04799	0.0936
Spacing (A)	3	0.09730 ^{NS}	1.13200**	3.40808**	3.5907**
Fertilizer (B)	2	0.53478 ^{NS}	1.92114**	9.82442**	12.3383**
Interaction (AxB)	6	0.00618^{NS}	0.14197**	0.20978**	0.3699**
Error	22	0.16989	0.15352	0.36487	0.1288

Appendix VI. Analysis of variance of the data on plant base diameter (cm), Days required for flower bud initiation, length of flowering stalk cm), (Diameter of flowering stalk (cm) of bunching onion influenced by combined effect of spacing and fertilizer

Source of variation	Degree of Freedom	Mean Square Value			
		Plant Base Diameter (cm)	Days required for flower bud initiation	Length Of Flower Stem(cm)	Diameter of Flower stem(cm)
Replication	2	1.03453	0.361	2.3326	3.05567
Spacing (A)	3	0.22493 NS	13.969**	46.0720**	0.13669 NS
Nutrients (B)	2	1.11506 NS	129.697**	33.7238**	0.34048 NS
Interaction (AxB)	6	0.09745 NS	0.872**	1.6001**	0.02273 NS
Error	22	0.83241	0.575	0.5518	0.65536

Appendix VII. Analysis of variance of the data on umbel diameter (cm), No. of umbel plant^{-1}, No. of flower plant^{-1}, No. of seeds umbel^{-1}of bunching onion influenced by combined effect of spacing and fertilizer

Source of variation	Degree of Freedom	Mean Square Value			
		Umbel Diameter (cm)	No of Umbel /plant	No of Flower/Plant	No Of Seeds/Umbel
Replication	2	0.10173	0.06966	38.27	963
Spacing (A)	3	0.91926**	0.56868**	950.37**	12461.1**
Nutrients (B)	2	2.80713**	4.79856**	3690.33**	29673.4**
Interaction (AxB)	6	0.07863**	0.04164**	56.80**	3852.2**
Error	22	0.0836	0.04089	46.99	562.8

Appendix VIII.

Analysis of variance of the data on seed yield plant^{-1}, seed yield. plot^{-1}, seed yield ha^{-1},1000 seed weight, seed germination % and dry matter content in leaves (%) of bunching onion influenced by combined effect of spacing and fertilizer

Source of variation	df	Mean Square Value					
		Seed Yield/plant(gm)	Seed Yield/Plot (gm)	Seed Yield/ha (kg/ha)	1000 Seed Wt (gm)	Seed Germination (%)	Dry matter content
Replication	2	0.00629	7.09	342	0.00591	42.194	0.17668
Spacing (A)	3	1.50568**	4545.21**	218914**	0.30923**	35.028 NS	2.34097 NS
Nutrients (B)	2	0.98842**	1412.53**	68032**	2.77802**	223.139 NS	5.61151 NS
Interaction (AxB)	6	0.06272**	134.38**	6472**	0.00613**	9.694 NS	0.14 NS
Error	22	0.01163	8.7	419	0.00932	20.619	0.08245

Appendix IX. Per hectare seed production cost of bunching onion

A (1) Input cost

Treatment combination	Labor cost	Ploughing	Seed cost	Irrigation	Weeding	Sticking	Insecticide	Sub total (A1)
S_1F_0	1,40,000	60,000	7500	40,000	10,000	40,000	20,000	3,17,500
S_1F_1	1,50,000	60,000	7500	40,000	10,000	40,000	20,000	3,27,500
S_1F_2	1,50,000	60,000	7500	40,000	10,000	40,000	20,000	3,27,500
S_1F_3	1,50,000	60,000	7500	40,000	10,000	40,000	20,000	3,27,500
S_2F_0	1,20,000	60,000	6000	40,000	10,000	40,000	20,000	2,96,000
S_2F_1	1,30,000	60,000	6000	40,000	10,000	40,000	20,000	3,06,000
S_2F_2	1,30,000	60,000	6000	40,000	10,000	40,000	20,000	3,06,000
S_2F_3	1,30,000	60,000	6000	40,000	10,000	40,000	20,000	3,06,000
S_3F_0	1,00,000	60,000	4500	40,000	10,000	40,000	20,000	2,74,500
S_3F_1	1,10,000	60,000	4500	40,000	10,000	40,000	20,000	2,84,500
S_3F_2	1,10,000	60,000	4500	40,000	10,000	40,000	20,000	2,84,500
S_3F_3	1,10,000	60,000	4500	40,000	10,000	40,000	20,000	2,84,500

A (2) Input cost

Treatment combination	**Cow dung**	**N**	**P**	**K**	**S**	**VC**	**PM**	**Sub total (A2)**	**Total (A1+A2)**
S_1F_0	30,000	0	0	0	0	0	0	30,000	3,47,500
S_1F_1	30,000	2000	4125	750	1100	60,000	0	97,975	4,25,475
S_1F_2	30,000	2000	4125	750	1100	0	30,000	67,975	3,95,475
S_1F_3	30,000	4000	8250	1500	2200	30,000	15,000	90,950	4,18,450
S_2F_0	30,000	0	0	0	0	0	0	30,000	3,26,000
S_2F_1	30,000	2000	4125	750	1100	60,000	0	97,975	4,03,975
S_2F_2	30,000	2000	4125	750	1100	0	30,000	67,975	3,73,975
S_2F_3	30,000	4000	8250	1500	2200	30,000	15,000	90,950	3,96,950
S_3F_0	30,000	0	0	0	0	0	0	30,000	3,04,500
S_3F_1	30,000	2000	4125	750	1100	60,000	0	97,975	3,82,475
S_3F_2	30,000	2000	4125	750	1100	0	30,000	67,975	3,52,475
S_3F_3	30,000	4000	8250	1500	2200	30,000	15,000	90,950	3,75,450

Cow dung @3tk/kg Urea @16tk/kg TSP @30 Tk/kg MOP @10tk/kg

Gypsum @20tk/k Vermicompost @10tk/kg Poultry manure @5Tk/kg

B) Overhead cost

Treatment combination	Cost of lease of land for 6 months (14% of value of land 1,20,000 Tk)	Miscellaneous cost (5% of total input cost)	Interest on running capital for 6 months (Tk. 14% of cost /year)	Sub total Tk. (B)	Total cost of production (Tk/ha) Total input cost [A (1) +A (2) +B]
S_1F_0	84,000	17,375	31421.25	1,32,796.3	4,90,296.3
S_1F_1	84,000	21273.8	37152.4	1,42,426.2	5,67,901.2
S_1F_2	84,000	19773.8	34947.4	1,38,721.2	5,34,196.2
S_1F_3	84,000	20922.5	36636.1	1,41,558.6	5,60,008.6
S_2F_0	84,000	16300	29841	1,30,141	4,56,141
S_2F_1	84,000	20198.8	35572.2	1,39,771	5,43,745.95
S_2F_2	84,000	18698.8	33367.2	1,36,066	5,10,041
S_2F_3	84,000	19847.5	35055.8	1,38,903.3	5,35,853.3
S_3F_0	84,000	15225	28260.75	1,27,485.8	4,41,985.75
S_3F_1	84,000	19123.8	33991.9	1,37,115.7	5,09,590.65
S_3F_2	84,000	17623.75	31786.9	1,33,410.65	4,85,885.65
S_3F_3	84,000	18772.5	33475.6	1,36,248.1	5,11,698.1