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Effect of Planting Date, Spacing and Nitrogen Level on Growth, Yield and Quality Seed Production of Onion (Allium cepa L.)

Begum, Mst. Sabina

University of Rajshahi

EFFECT OF PLANTING DATE, SPACING AND NITROGEN LEVEL ON GROWTH, YIELD AND QUALITY SEED PRODUCTION OF ONION (*Allium cepa* L.)

A THESIS SUBMITTED FOR THE DEGREE
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BY

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Examination Roll No. 06611
Registration No. 0504
Session: 2006-07

MAY, 2011

DEPARTMENT OF AGRONOMY
AND AGRICULTURAL EXTENSION
RAJSHAHI UNIVERSITY
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DEDICATED
TO MY AFFECTIONATE SON
SHADID

DECLARATION

I do hereby declare that the whole work submitted as thesis entitled **"Effect Of Planting Date, Spacing and Nitrogen Level On Growth, Yield and Quality Seed Production Of Onion (*Allium Cepa* L.)"** in the Department of Agronomy and Agricultural Extension, University of Rajshahi, Bangladesh, for the degree of Masters of Philosophy in the Department of Agronomy and Agriculture Extension, in the result of my own investigation and was carried under the supervision of Dr. Md. Arifur Rahman, Associate Professor, Department of Agronomy and Agricultural Extension, University of Rajshahi, Rajshahi, 6205, Bangladesh. No part of the work referred to in the thesis has been submitted in the support of an application for another degree of qualification of this of any other university or other institution of learning.

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CERTIFICATE

This is to certify that the authoress herself did the entire work now submitted as a thesis for Masters of Philosophy (M.Phil), University of Rajshahi. The materials included in this thesis are original and was not submitted before for any other degree.

25.5.2011
Dr. Md. Arifur Rahman
(Supervisor)

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The Author

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ACRONYMS

a.i.	–	Active Ingredient
AEZ	–	Argo-ecological zone
BAU	–	Bangladesh Agricultural University
BARI	–	Bangladesh Agricultural Research Institute
CM	–	Centimeter
°C	–	Degrees Celsius
CV	–	Co-efficient of variation
CCS	–	Conventional Cropping System
DAP	–	Days After Planting
DAE	–	Department of Agricultural Extension
DAS	–	Days after Sowing
MRT	–	Duncan's Multiple Range Test
et al.	–	And others
ECS	–	Ecological Cropping System
FAO	–	Food and Agriculture Organization
Fig.	–	Figure
g	=	Gram
ha^{-1}	–	Per Hectare
m	–	meter
m^2	–	Square meter
i.e.	–	That is
mm	–	Millimeter
MP	–	Muriate of Potash
NS	–	Not significant
pH	–	Negative logarithm of hydrogen ion (H^+) concentration
t	–	Ton
TSP	–	Triple Super Phosphate
UNDP	–	United Nations Development Programme
viz.	–	Videlicet =namely
/	–	Per
%	–	Percent

ABSTRACT

The experiment was conducted at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi during the period from October 2008 to April 2009 to study the effect of planting date, plant spacing and levels of nitrogen on the growth, yield contributing characters, yield and quality of onion seed. There were three planting dates viz. November 05, November 25 and December 15; four plant spacings viz. 25cm x 10cm, 20cm x 15cm, 25cm x 15cm and 25cm x 20cm and four nitrogen levels viz. 0 Kg ha^{-1}, 100 Kg ha^{-1}, 150 Kg ha^{-1} and 200 Kg ha^{-1}. The experiment was laid out in Split-Split plot Design having three replications. The planting dates were assigned in the main plots, plant spacing in the sub plot and the nitrogen level in the sub- sub plots. The size of each unit plot was 1.5 m × 1.0 m.

The results of the experiment revealed that planting date had significant effect on all the parameter studied except plant heights at 30 DAP. Plant spacing and nitrogen levels were also significant on vegetative growth, yield contributing traits, yield and quality of onion seed. Planting date November 05 gave the tallest plant, highest number of leaves $plant^{-1}$, tillers $plant^{-1}$, number of umbels $plant^{-1}$, number of flowers $umbel^{-1}$, number of seeded fruits $umbel^{-1}$, highest percentage of fruit set, seed weight $umbel^{-1}$, thousand seed weight, germination percentage of seeds and finally produced highest seed yield (482.46 Kg ha^{-1}). The lowest values of all the parameters were found in the planting date December15 except days to 50% bulb emergence. Planting bulbs with closer spacing gave the highest seed yield unit $area^{-1}$ whereas bulbs with wider spacing produced the highest seed weight $plant^{-1}$. The closest spacing of 25 x 10 cm^2 produced the highest seed yield ha^{-1}(501.39 kg) but the seed yield $plant^{-1}$ was higher (1.41g) in widest spacing of 25 x 20 cm^2. The vegetative growth as well as seed production ability of the plants was increase gradually with the increase of nitrogen level. The highest seed yield ha^{-1}(489.39 kg) and yield contributing characters were found by the application of highest dose of nitrogen (200 Kg ha^{-1}) followed by 150 Kg ha^{-1} and 100 Kg ha^{-1}. The lowest values of all the parameters were found in control (0 Kg ha^{-1}) except days to 50% bulb emergence.

The combined effect of planting date and plant spacing, planting date and nitrogen levels and plant spacing and nitrogen levels were significant for most of the parameters studied. Due to the combined effect of planting time and spacing, seed yield unit area^{-1} was increased with early planting and closest plant spacing. The highest yield and quality of the seed was recorded from November 5 with closest spacing 25 x 10 cm^2. The maximum yield and quality of the seed was obtained from the bulb planting at November 5 with 200 kg N ha^{-1}. Due to the combined effect of spacing and nitrogen levels, the seed yield was increased with reduction in spacing and increase of nitrogen level. The highest amount of seeds was found in the treatment combination of the closest spacing of 25 x 10 cm^2 with highest doses of nitrogen (200 kg N ha^{-1}) but the superior quality seed was produced from the combination of wider plant spacing of 25 x 20 cm^2 with highest doses of nitrogen (200 kg N ha^{-1}).

Chapter One

Introduction

INTRODUCTION

Onion belongs to the genus *Allium* and family Alliaceae (Hanelt, 1990). There are more than 500 species within the genus *Allium*. Of these, most are bulbous plants. Onion (*Allium cepa* L.) is an important herbaceous bulb crop in the world. It has been cultivated for 5000 years or more and does not exist as a wild species (Brewster, 1994). Of the 15 vegetable and spice crops listed by FAO, onion ranks third (46,750 thousand mt) only after tomato (1, 00,259 thousand mt) and cabbage (54,503 thousand mt) in terms of annual world production in the year of 2001 (FAO, 2002[a]). The demand for onion is world wide and fairly constant. Their use is not limited to any climate or associated with any nationality and they are probably as widely grown as any cultivated crop. They are used in every home, almost daily primarily as a seasoning for wide variety of dishes. Onion is grown, traded and consumed in most countries of the world because of their economic importance.

In Bangladesh, onion is used not only as spice crop but also used as vegetable. It has some medicinal value. The main edible portion is the bulb, which is a modified organ consisting of thickened fleshy scale leaves and the stem-plate (Jones and Mann, 1963). The leading onion producing countries are China, India, United States of America, Turkey, Russia, Pakistan, Japan, Brazil, Spain, Korea, Netherlands, Morocco, Egypt, Nigeria and Italy (FAO, 2006). Onion is grown in all parts of Bangladesh but commercial cultivation is found mostly in the greater districts of Faridpur, Pabna, Comilla, Dhaka, Rajshahi, Mymensingh, Rangpur and Jessore (BBS, 2006). Among the spice crops grown in the country, onion ranks first (36,842 ha) next to chilli (38,138 ha) in area and top (1,50,000) in production during the year of 2001-2002 (BBS, 2003). The average yield of onion in Bangladesh is very low (3.94 t ha^{-1}) as compared to the world average yield (17.10 t ha^{-1}) (FAO, 2001).

Onion production in Bangladesh during the year 2008-2009 was 735140 metric tones from 266255 acres of land with an average yield of 6.82 t ha^{-1} (BBS, 2009) which was quite lower than other onion producing countries of the world, such as Korea Republic (60.93 t ha^{-1}), Australia (48.35 t ha^{-1}), China (22.85 t ha^{-1}), Japan (50.40 t ha^{-1}),USA (9.00 t ha^{-1}), Germany (32.57 t ha^{-1}), Egypt (27.39 t ha^{-1}), and India (9.44 t ha^{-1}) (FAO, 2006). The total production of onion is much less compared to the estimated annual demand of 4, 50,000 mt (Ara *et al.*, 2000). This production does not fulfill the country's demand. As much, a huge amount of onion needs to import to meet the demand with the expense of our hard earned foreign currency. The authorized import was 30,000 mt in the year of 2000 costing 85,00,000 US Dollar (FAO, 2002). The shortage of onion in the country is largely due to unavailability of required quantity of quality seeds. So increasing the seed yield should be the primary consideration in respect of onion production in Bangladesh. Seed is the basic and essential input for any crop production. According to Thompson (1979), high quality seed is a critical input on which all other inputs will depend for their full effectiveness. The main problems associated with the shortage of high quality seeds are: unpredictable weather conditions, planting time, want of suitable varieties, efficient use of fertilizer mainly nitrogen, cultural practices to be adopted etc. In Bangladesh, seed yield of onion is very low (370 to 500 kg ha^{-1}) (HRDP, 1995) as compared to the yield (1000 to 1200 kg ha^{-1}) of some other countries of the world (Brewster, I 994).

There are two methods of onion seed production, viz. 'seed-seed' and 'bulb-seed' method. The seed-seed method reduces the cost for planting material but all the plants raised from seeds do not bear inflorescence in the first year in Bangladesh (Rahim *et al.*, 1982) which reduces the seed yield drastically. This makes the bulb-seed method more preferable and it is being practiced by the commercial seed growers.
Onion production can be increased mainly in two ways. Firstly, by extending the land area under cultivation, and secondly, by increasing the productivity of the crop. As the cultivable land area is limited in Bangladesh, it is not possible to extend the land under onion cultivation. Yield and quality of onion seed is greatly affected by the environmental conditions during growth and development of plant, because different growth phases have different environmental optima. This phenomenon makes the planting time as the prime factor for onion seed crop. Practically onion bulbs are planted during rabi season for seed production. In case of early planting heavy dews adversely affect the onion seed crop. Contrarily late planted crop experiences early rain and northwester almost every year which lead to total crop failure. Proper planting time for onion seed crop greatly varies with the locality and even from year to year at the same place.

Judicious application of fertilizers is important for production of onion. Among the nutrients, nitrogen is the most limiting nutrient in crop production. It increases the vegetative growth and produces adequate quality of foliage and promotes carbohydrate synthesis (Rai, 1981) which might help to produce high yield and quality onion seed. Optimum nitrogen application helps growth of onion seed crop rapidly and bolts earlier, which results in early maturation of seed. Reports indicate that, both yield and quality of onion seed can be improved to a great extent by using nitrognous fertilizers (Bokshi *et al.*, 1989, Pandey *et al.*, 1992 and Rahirn *et al.*, 1997). Optimum nitrogen fertilized onion seed crop grows rapidly and bolts earlier, which results in early maturation of seed.

'Taherpuri' is a local variety of onion growing widely throughout the country. Seeds of this variety are produced by bulb to seed method in particular areas of Bangladesh. The available information on the effects of planting time, spacing and plant nutrients particularly of nitrogen level on seed production of onion under Bangladesh condition is not conclusive. A detailed and systematic study is needed to find out the appropriate planting time, fertilizer doses and different management practices such as planting density for quality seed production of onion.

In view of the above facts, the present investigation was undertaken with a view:

i) to optimize the planting date of onion seed crop for the cultivar Taherpuri;

ii) to know the appropriate spacing to be adopted for seed production of onion;

iii) to determine the optimum level of nitrogen for satisfactory yield of quality onion seed and

iv) to find out the combined effect of planting date, spacing and nitrogen levels, if possible.

Chapter Two

Review of Literature

REVIEW OF LITERATURE

Onion was domesticated almost at the dawn of civilization. It was regarded as one of the most important vegetables as well as spices of the world. Its economic importance in the world trade (FAO, 1999[b]) signifies also its elevated position amongst vegetable and spices crops. Cultivation of onion (both for bulb and seed production) has been quite extensive under different agro-climatic and socio-economic conditions prevailing globally. Because of continuous efforts rendered by the scientists all over the world, generation and adoption of onion seed production technology had been quite diverse. Literature on onion seed crop, most pertinent to this thesis works have been reviewed here under the follows headings.

2.1 Effect of planting date on growth, yield and quality of onion seed crop

Optimum planting lime is one of the most important factors for quality seed production of onion and it may vary greatly with the geographic as well as agro-ecological conditions.

Singh *et al.* (1974) conducted an experiment to investigate the optimum planting time for, onion seed crop in Haryana, India and reported that first and second weeks of October plantings yielded the highest and it was declined as the planting was delayed till November 12.

Rathore *et al.* (1975) obtained the highest seed yield of onion for November 2 planting under the climatic condition of India when mother bulbs were planted on several dates between October 5 and November 16.

Singh *et al.* (1977) reported to obtain maximum seed yield from the bulbs planted on October 22 while bulbs were planted on October 22, October 29 and November 5 in Agra, India.

Mondal and Husain (1980) conducted an experiment at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh during the period from September 1977 to April 1978 to investigate the optimum planting time of onion mother bulb for seed crop. Bulbs were planted on October 13, October 23, November 3 and November 13: They reported that October 23 was the best planting time for the highest yield of best quality seed.

Lal *et al.* (1982) obtained 350, 260, 190, 99 and 45 kg onion seed per hectare for October 13, October 20, October 27, November 4 and November 11 plantings, respectively in UP, India.

Paiva and Costa (1982) reported planting onion sets in July/August and harvesting in October/November resulted in good seed yields in Brazil.

Singh and Singh (1984) mentioned that the highest seed yield (2.2 t/ha) was obtained from 15 November (at 30 x 10 cm spacing) while mother bulbs were planted on November 1, 15 and 30 in South India.

Similarly Mishra (1986) obtained the highest seed yield and best seed quality for onion bulbs planted on September 15 and this was declined as the planting was delayed until November 15 in Muzaffarpur, India.

Mohamedali and Nourai (1988) conducted a research in Sudan, and that the period from mid-October to mid November was the optimum time of onion bulb planting for seed production under the climatic conditions.

Gill *et al.* (1989) planted onion bulbs of different grades on October 1, October 15 or November 1 in India and observed that planting date affected seed yield significantly and the highest seed yields were obtained from the October plantings.

Nehra *et al.* (1989) reported the highest number of scapes plant^{-1} (9.8), seed yield umbel^{-1} (3.16 g), seed yield plant^{-1} (18.97 g) and seed yield ha^{-1} (1369 kg) with bulbs planted on. October 16. (bulbs were planted on October 16 and November 15) and declined as planting was delayed until November 15 in the agro-climatic conditions of Haryana, India.

Krisnaveni *et al.* (1990) conducted an experiment under the climatic condition of Bhavanisagar, India to investigate the optimum planting time for onion seed crop and stated that planting in the second and third weeks of November gave the highest seed yield as well as the best seed quality (86.0-90% germination). While sets were planted at weekly intervals between the second week in November and fourth week of February. No seed yield was obtained from sets planted after the third week in January.

Mathankar *et al.* (1990) conducted an experiment under the climatic conditions of Akola, India, to find out the optimum planting time for onion seed crop. They planted seven onion cultivars (Pusa Red, Pusa White Flate, Pusa Ratnar, SI 102, N-53, N-257-9-1 and Selection Local White) at four planting dates (November 26, December 11, December 26, 1983 and January 10, 1984). The highest plant height (74.7 cm), number of leaves per plant (65.7), number of flower stalks per plant (7.9), diameter of the primary umbel. (8.2 cm), mean number of seeds per primary umbel (984.9), seed yield per plant (18.7 g) and seed yield per hectare (2750 kg) were resulted from the first planting (November 26).

Bhonde *et al.* (1991) planted onion cultivar Agrifound Dark Red on November 1, 15 and 30 and December 15 in field trails in Jaipur (Rajasthan), Karmal (Haiyana) and Nasik (Maharashtra) of India in the rabi (winter) seasons of 1987-88 and 1988-89 and obtained the highest seed yields for planting on November 1 in Jaipur, November 15 in Nasik and December 15 in Karmal (770, 638 and 430 kg, respectively) per ha. In another experiment Mehra *et al.* (1990) obtained maximum seed yield from the plants raised from bulbs planted on September 25 (1475 kg per ha) and October 10 (1495 kg per ha) while bulls were planted on August 25, September 10, September 25, October 10 or October 25 at Hisar, India for two growing seasons.

Roy (1994) planted onion mother bulbs on November 1, November 15 and November 30 and reported that the highest seed yield (677.18 kg) per ha was obtained from November 15 plating while November 1 planting showed the highest percentage of seed germination (65.05%). She did not observe significant difference in seed yield as well as per cent germination between November 1 and 15 plantings.

Begum (1995) observed the highest seed yield (158.68 kg) ha^{-1} of onion seed crop for October 31 planting and the lowest (65.74 kg) ha^{-1} for November 25 planting in Mymensingh, Bangladesh.

Alam (1995) obtained maximum yield $plant^{-1}$ (0.85 g) and yield ha^{-1} (233.94 kg) for November 2 planting but October 10 planting gave indifferent results, for the same in Mymensingh. The highest germination percentage (72.64%) and 1000- seed weight were observed for November

2 planting and both the parameters gave lowest results for November 23 planting.

Abedin (1995) noticed that the highest seed yield of 773.6 kg ha^{-1} was for mother bulb planting on November 15 and that of the lowest (696.1) kg ha^{-1} for November 30 planting at the same place.

Farghali (1995) carried out trials during the 1993-94 and 1994-95 seasons with onion cultivar Giza 6 in Assuit, Egypt. Mother bulbs were planted either whole or after removing the upper third on September 1, October 1 or November 1 in both seasons.

Rizk *et al.* (1996) studied the effect of dates of planting and some growth regulators on seed yield of onion in Egypt and reported to have greatest seed stalk height and diameter, umbel diameter and average number of flowers per umbel from early planting (bulbs were planted during the first, second or last 10 days of November). Delaying the time of planting to the last 10 days of November reduced seed yield compared with the other 2 planting date treatments. Percentage of germination of the seeds produced and 1000 seed weight tended to decrease' with delay in bulb planting date.

Jun *et al.* (1996) observed that the highest plant growth and seed set for plants planted on 25 September in Korea.

UD-DEEN (2008) planted Onion bulbs of different sizes (20g, 15g and l0 g) at different dates viz., 30 October and 15 and 30 November to observe their effects on growth, bulb and seed yield of onion. The mother bulb size and planting dates showed significant influence on growth, bulb and seed yield of onion. The large mother bulb and early planting were favourable for getting higher bulb and seed yields. The treatment combinations of large mother bulb (20 g) and 30 October planting time gave the highest bulb (17.52 t /ha) and seed (402.80 kg /ha) yield.

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

2.2 Effect of plant spacing on growth, yield and quality of onion seed crop

Patil (1960) observed the highest seed yield with a 'spacing of 30.5x l6cm.

Khandalwal and Maiti (1971) obtained higher seed yield (1500 kg ha^{-1}) from closer spacing of 30 x l5cm.

Singh *et al.* (1974) recorded the highest total yield from the spacing of 30x10 cm. They planted bulbs at the spacing of 10, 15, 20, 25, 35 and 40cm in 30 cm apart rows. They also found the number of flowering stalks $plant^{-1}$ was higher under wider spacing.

Singh and Singh (1984) found the highest total yield (1.2t ha^{-1}) from the closest spacing of 30xl0cm. Bulbs were planted at 30 x 30cm, 30 x 20cm and 30 xl 0cm by them.

Sarnaik *et al.*(1985) noticed that although the seed yield unit area^{-1} was the highest (948.25 kg ha^{-1}) with the 15 x 15cm spacing, the highest net profit was obtained at 45 x 15cm with a seed yield of 727 kg ha^{-1}.

Steiner (1986) reported increasing plant spacing increased the final seed yield. He planted bulbs of cv. Gala at 12, 24, 48 or 72cm apart in single rows in beds 1 m apart. He found that increasing plant spacing resulted in a greater number of flowering stalks unit area^{-1} which increased. He also reported that there was no effect of plant population on seed quality.

Nagaraju *et al.* (1986) obtained the highest seed yield (411 kg ha^{-1}) at the spacing of 60 x 15cm. They planted bulbs at the spacing of 60x15, 60x22.5, 60x30 and 60x37.5cm.

Lal *et al.* (1987) recorded the highest seed yield per hectare at the spacing of 30x30cm. They planted bulbs at the spacing of 30x30, 30x45 and 45x45cm. He also reported spacing showed significant effect on plant height. The maximum number of flowering stalks plant^{-1} was produced at closer spacing.

Amiroddin *et al.* (1988) also found that plant spacing had no significant effect on 1000-seed weight and seed germination.

Nehra *et al.*(1988) found closer spacing (30cm) significantly produced higher yield compared to medium (40cm) and wider (50cm) spacing. Closer spacing (30 and 40 cm) significantly increased plant height over that for wider (50cm) spacing. They also observed the number of flowering stalks plant^{-1} was higher under wider spacing.

Cuocolo and Barbieri (1988) stated that an increase of plant density form 4 to 12 bulbs/rn^2 gave a linear increase of overall seed yield from 700 to 1200 kg/ha.

Bhonde *et al.* (1989) found the highest seed yield (624 kg/ha) from plants spaced at 45x30 cm. They planted bulbs at the spacing of 45x30, 60x30 and 60x45cm.

Singh *et al.*(1990) reported the highest planting density (30x30cm) gave a significantly higher seed yield per unit area (991 kg ha^{-1}) compared with the other spacing which were (30 x 45, 30 x 60, 45 x 45, 45 x 60 and 60 x 60 cm).

Bhardwaj (1991) obtained the highest seed yield plot^{-1} (641.60g) was at 30x30cm. They also found the number of flowering stalks plant^{-1} was higher under wider spacing.

Pandey *et al.* (1992) found the closest spacing (45x30cm) gave the highest seed yield compared to other spacing such as 60x30 and 60 x 45cm.

Singh *et al.* (1993) observed the highest seed yields (664 and 656 kg ha^{-1}) were obtained at 30x30cm with nitrogen at 120 and 80kg ha^{-1}, respectively. They planted bulbs at 5 spacing such as 30x30, 45x30, 45x45, 60x30 and 60x45cm.

Ali *et al.* (1998) stated that the yield ha^{-1} (335.65kg) was the highest from plants at the narrowest spacing (10cm) followed by plants spaced at 30cm distance (296.53kg). They planted bulbs at 5 spacing such as, 10, 15, 20, 25 and 30cm. He also found that 1000- seed weight (2.12g) was significantly higher in plant spacing at 30cm compared to those spaced at 10cm (1.84g). They planted bulbs at 5 spacings (10, 15, 20, 25 and 30cm).

Dadhania and Gajipara (1998) found the highest plant height (58.60cm) at the spacing of 60x30cm. They planted bulbs at 4 spacings such as 30x30, 45x30, 60x30 and 60x45cm. They also found the number of flowering stalks plant^{-1} was higher under wider spacing.

Singh and Sachan (1999a) found that the closest spacing (l5x30cm) gave much the greatest seed yield per hectare compared to other spacings such as 30x30 and 30x45cm He also observed seed germination percentage was not significantly affected by plant spacing.

Singh and Sachan, (1999^{b}) obtained the highest seed yield ha^{-1} (1428kg) with the smallest spacing of 30xl5cm. They used three spacing combinations such as, 30x15, 30x30 and 30x45cm. The greatest number of leaves per plant (60.67) was recorded at the widest spacing of 30x45cm. They also found the number of flowering stalks plant^{-1} was higher under wider spacing.

Gupta and Sharma (2000) determined the effect of different spacings and levels of fertilizers on yield, quality and storage of onion cv. Agrifound Light Red. Treatments comprised 3 spacings (10 x 5, S_1; 10 x 7.5, S_2; and 10 x 10 cm, S_3) and 3 NPK rates (75:50:50, 100:50:50 and 125:50:50 kg/ha). S_1 had the highest plant stand per plot, which was about 44% higher than that of S_2 and 88% higher than that of S_3. S_1 recorded the thinnest neck and lowest double bulbs. Although plant height, leaf number, bulb diameter were highest in S_3, the gross and marketable yields were highest in S_1 by virtue of higher plant population. It recorded an 11 and 17% higher gross yield and 10 and 16% exportable bulb yield than S_2 and S_3, respectively. Although S_1 had high disease and thrips incidence and intensity, its yield was not much affected. The effect of bolting and total soluble solids (TSS) was not significantly different. A higher N level recorded a higher plant height, leaf number, bulb diameter, bulb size index, weight of 20 bulbs and yield and a had low disease incidence and intensity. The different N rates did not show significant differences on bolting, doubles, TSS and thrips incidence. S_1 and 100:50:50 kg NPK ha^{-1} recorded the highest yield and net return. Different spacings and N levels did not significantly affect bulb storage behaviour. The net return was highest in S1 and 100:50:50 kg NPK ha^{-1} rate mainly by virtue of highest marketable bulb yield and highest recovery of marketable bulbs per hectare after storage.

Kanwar *et al.* (2000) conducted an experiment in Punjab on 8 dates from 1 September to mid-December at fortnightly intervals, and at 3 levels of plant density (45 x 30, 60 x 30 and 60 x 60 cm). Onions sown on 1 October were the longest to flower and mature (126 and 168 days, respectively), while those sown on the first fortnight of December flowered in 85-90 days and were harvested in around 130 days. The highest number of umbels per plant were produced on onions sown from October to mid-November; earlier or later sowings had lower umbel numbers. The 1 November sowing date gave the highest seed yield (1004.90 kg/ha), as did the 45 x 30 cm spacing (1048.70 kg ha^{-1}).

Kumar *et al.* (2001) conducted an experiment in Uttar Pradesh, India, during 1992-93 and 1993-94 to determine the effect of different spacing densities (20x10, 20x15 and 20x20 cm) on onion cv. Pusa Red growth and yield. The highest bulb yields (279.72 and 273.43 q ha^{-1}) were obtained with 20x20 cm spacing. Growth parameters and bulb characters were better in the 20x20 cm spacing compared to narrower spacing densities.

Ushakumari *et al.*(2001) studied the effects of spacing (10x10, 15x10, and 20x10 cm), herbicides (1.0 kg pendimethalin/ha, 1.0 kg alachlor/ha, or 0.15 kg oxyfluorfen/ha + hand weeding at 40 days after planting or DAP), and hand weeding at 20, 40, and 60 DAP on onion and associated weeds (Cyperus rotundus, Cynodon dactylon, Commelina benghalensis, Dactyloctenium aegyptium, Parthenium hysterophorus, Tridax procumbens, and Euphorbia hirta) in Rajendranagar, Andhra Pradesh, India, during the rabi season of 2000/2001 . The total bulb yield, dry matter, leaf area index, and crop growth rate significantly increased with the decrease in spacing. All herbicides were effective in reducing weed density and dry matter at all stages of crop growth and in enhancing yield and yield components. The highest bulb yield was obtained with hand weeding at 20, 40, and 60 DAP.

Khan *et al.* (2002) reported that various plant spacing resulted in the increased plant height, onion bulb size, weight of the bulbs, number of the bulbs per plot and yield of the bulbs. In case of different nitrogen levels, all the parameters under the study were significantly affected. However, 12 cm plant spacing with 100 kg N ha^{-1} gave the best results. Maximum yield of onion bulbs (22.90 and 22.82 t ha^{-1}) was obtained from 12 cm plant spacing with 100 kg N ha^{-1}, respectively.

Tiwari *et al.* (2002) determined the effects of N (0, 40, 80 and 120 kg/ha) and plant spacing (45 x 30, 60 x 30 and 60 x 45) on the yield of onion cv. Pusa Red in a field experiment in Pantnagar, Uttaranchal, India during 1996-98. Plant height, length of flowering stalk, number of umbels per bulb, 1000-seed weight, purple blotch and seed yield increased with increasing rates of N up to 80 kg ha^{-1}. Spacing of 60 x 45 gave the highest number of leaves per plant (12.10) and 1000-seed weight (2.88 g), whereas the spacing of 60 x30 and 45 x 30 gave the highest length of flowering stalk (93.45 cm) and seed yield (9.28 q ha^{-1}), respectively. The interaction effects between application of N at 80 or 120 kg ha^{-1}, in combination with the closest spacing resulted in the highest yield and cost: benefit ratio.

Hemlanaik and Hosamani (2003) conducted an experiment to know the effect of spacing and various nitrogen levels on growth and yield of kharif onion (*Allium cepa* L.) under rainfed condition of Dharwad region. Three spacing (15 x 10 cm, 15x15 cm and 15 x 20 cm) with four levels of nitrogen (N) (O,50,100 and 150 kg ha^{-1}) were tried . Among the spacing and N levels tried, narrow spacing of 15 x 10 cm with application of 150 kg N/ha was found to be the optimum in enhancing the onion yield (169.02 q ha^{-1}) and other growth and quality parameters like plant height, number of leaves, bulb length, bulb diameters and total soluble solid of the bulb. And also maximum net return and benefit: cost ratio was also found in the same treatment combination.

Naik and Hosamani (2003) conducted an experiment during 1997-98 and 1998-99 to investigate the effect of spacing (15x10, 15x15 and 15x20 cm) and N level (0, 50, 100 and 150 kg ha^{-1}) on the growth and yield of kharif onion under rainfed condition of Dharwad, Karnataka, India. They reported that Narrow spacing of 15x10 cm with application of 150 kg N ha^{-1} was found optimum for enhancing yield (169.02 q ha^{-1}) and other growth and quality parameters, such as plant height, leaf number per plant, bulb length, bulb diameter and bulb total soluble solid content.

The maximum net return and benefit cost ratio were also recorded from this treatment combination.

Kumar and Singh (2007) conducted a field experiment in Uttar Pradesh, India, during 2002/03 and 2003/04 to study the effect of bulb size (3.0-4.0, 4.0-5.0 and 5.0-6.0 cm), cultivar (Hisar-2 and Nasik red) and spacing (30x10, 30x20 and 30x30 cm) on the growth and seed yield of onion. They reported Hisar-2 bulbs of 5.0-6.0 cm and sown at 30x30 cm spacing gave maximum number of flowers head^{-1}, number of seeds umbel^{-1}, seed weight per umbel^{-1}, seed yield, plant height, number of shoots plant^{-1}, shoot diameter and number of leaves plant^{-1}, and earliest days to first umbel formation.

May *et al.*(2007) was conducted an experiment arranged in factorial 2 x 4 x 4 x 4, respectively correspondent by cultivars (Optima and Superex), nitrogen (0; 50; 150 and 150 kg ha^{-1} of N), potassium (0; 75; 150 and 225 kg ha^{-1} of K_2O) and planting density (60; 76; 92 and 108 plants m^{-2}). The experimental design was of randomized blocks, with four replications The fertilizers ammonium nitrate and potassium chloride were employed to provide N and K, respectively. The nitrogen and potassium application reduced to near to zero the incidence of non-comercial bulbs in both cultivars. The largest percentage of bulbs measuring 50 to 70 mm was reached with 60 plants m^{-2} and application of 150 kg ha^{-1} of N, mainly for cv. Superex. Cultivar Superex presented the largest quantity of double bulbs, with the application of 150 kg ha^{-1} of N (17% of the total bulbs produced) and plant population of 60 plants m^{-2} (22% of the total bulbs).

2.3 Effect of nitrogen levels on growth, yield and quality of onion seed crop

Amiroddin *et al.* (1988) conducted an experiment was conducted by in Karnalaka. India to study the effect of spacing and nitrogen levels on seed quality 01 onion cv. Bellary Red. Plant in rows 10, 20 or 30 cm apart received N at 0. 30, 50 or 90 kg ha^{-1}. One-half of the N rate and the basal rate of 60 kg P_20_5 + 60kg K_20 ha^{-1} were the remaining N was top dressed one month later. They found that different treatments had no significant effect on 1000 seed weight, seed germination and seedling vigour.

Cuocolo and Barbieri (1988) reported that adequate nitrogen fertilization is essential for maximum seed yield of onion. They carried out a field experiment to evaluate the effects of six levels of nitrogen viz. 0, 30, 60, 90, 120 and 150 kg ha^{-1} and five plant densities viz.4, 6, 8, 10 and 12 bulbs/m^2 on seed yield of cv. Amposta in Italy. The nitrogen was applied as anmonium sulfate, one-third at planting in mid-October, one-third in late March and one-third in late March. Seeds were harvested in July. It was observed that seed yield increased linearly from 830 to 1100 kg ha^{-1} with increasing N level.

Mohamedali and Nourai (1988) studied the effects of bulb sour, sowing date and nitrogen nutrition on the seed yield of the white dehydration onion in the Sudan. The bulb sources used were whole bulbs and stmi multiplied bulbs. Whole bulbs gave consistently higher seed yields 548 -1259 kg ha^{-1} than summer multiplied bulbs 396-746 kg ha^{-1}. The optimum planting dates were mid October to mid November. Nitrogen fertilization from 046 kg ha^{-1} increased the seed yield.

Nehra *et al.* (1988) conducted a field trial over two years on the effect of bulb size, spacing and nitrogen on plant growth and seed yield with onion cv. 'Hissar-2' in Haryana, India. They stated that application of 40 and 80 kg N/ha significantly increased plant height, number of leaves sprouts and scape per plant, diameter of umbel and seed yield compared with the zero-N control; the differences in effect between 40 and 80 kg N were not significant except that kg N increased the number of leaves per plant over 40 kg N.

Singh *et al.* (1988) investigated the effect of various levels of nitrogen, spacing and their interaction on seed crop of onion cv. Pusa Red in Faizahad, India. They used three plant spacing (45 x 30, 60 x 30, 60 x 45 cm) and four levels of nitrogen (0, 40, 80 and 120 kg ha^{-1}). The N dose was split, with one-third applied as a basal dressing with the remaining 2 doses applied 30 and 60 days after planting. They reported that highest seed yield (8.65 q ha^{-1}) was obtained from plants spaced at 45x3O cm and receiving 40 kg N ha^{-1}.

Rhonde *et al.* (1989) in India to study the effect of spacing anti levels of nitrogen on seed yield of cv. Pusa Red onion. in their experiment plants spaced at 45x30, 60 x 30 and 60x45 cm received at 0-120 Kg N/ha with basal P205 : K20 at 50: 60 kg ha^{-1}. half of the N was applied at planting and the remainder as a top dressing 50 days later. It was observed that the highest seed yield, 6.24 q ha^{-1} was obtained from plants spaced at. 45 x 30 cm and receiving N at 80 kg ha^{-1}.

Bokshi *et al.* (1989) conducted a field trial at Myrnensingh with cv. Faridpur Bhati, uniform bulbs, about 10g in weight and 28 mm in diameter, were planted on 10 November and given N and P_20_5, each at 0, 100, 150 and 200 kg ha^{-1} together with a basal dressing of 80 kg K 20/ha. One third quantity of each of N was applied during the final preparation of land. The remainder of the N was applied as top dressing in two installments after 30 and 60 days of planting. Nitrogen was used as urea. They found that the plants fertilized with 200 kg ha^{-1} of N produced the highest number of leaves, maximum number of flower per umbel and the plant fertilized with 150 kg/ha of N produced the highest number umbel per plant, took shortened days to emergence of 50% flower stalk. They also found that the highest seed yield of 529.7 kg ha^{-1} and the maximum germination (83.7%) were obtained with N and P at the highest rates.

Bhardwaj *et al*. (1991) conducted a field experiment during winter season of 1986 and 1987 at the experimental farm of Dr. Y. S. Parmar University of Horticulture and Forestry, Solan to study the effect of different levels of nitrogen, phosphorus and depth of bulb planting of seed production in onion cv. Nasik Red. Three levels of nitrogen viz. 40, 80, 120 kg N/ha, four levels of phosphorus viz. 0, 30, 60 and 90 kg P2051ha and two planting depth viz. 2.5 and 5 cm below soil surface were used. Half dose of nitrogen and full dose of phosphorus was applied in the soil at the time of field preparation and. remaining nitrogen applied in two splits i.e. half at the time of scape emergence and half at flowering. They stated that nitrogen application had significant effect on all the characters studied. The number of days to scape emergence were significantly reduced with the increasing levels of nitrogen. Plant height increased with the increasing levels of nitrogen. The main yield contributing characters were the number of scapes per plant, size of umbel and weight of seeds per umbel, which were significantly increased by higher nitrogen levels but the increase beyond 80 kg N ha^{-1} was not significant.

Malachaowski (1975) and Singh *et al.* (1965) were also found similar results.

Maier *et al.* (1990) reported the effect of nitrogen (N), at rates up to 590 kg N/ha, on the yield and quality of Cream Gold onions grown on siliceous sands was investigated in field experiments conducted during 1987-88 (1 site) and 1988-89 (2 sites). As the rate of applied N increased there was a significant ($P<0.001$) increase in the fresh weight of tops harvested when the largest bulbs were 25-30 mm in diameter. Fresh weight of tops was significantly ($P<0.001$) correlated with final marketable yield of bulbs. Nitrogen application accelerated top senescence. Nitrogen-deficient plants had erect green tops at harvest. Marketable yield was significantly ($P<0.01$) increased and the yield of culls (unmarketable bulbs) was significantly ($P<0.01$) decreased as the rate of N increased at all sites. Nitrogen rates in the range 299-358 kg N/ha were required for 95% of maximum yield. Scale thickness increased significantly ($P<0.05$) and glucose and fructose concentrations decreased significantly ($P<0.05$) at 2 sites as the rate of applied N increased. Soluble solids and dry matter of bulbs were not affected by N. Bulb size increased as the rate of applied N increased, however, the magnitude of the effect varied between sites. Number of days to 10% sprouting during storage at 15 ¦ 0.5¦C was significantly increased as the rate of applied N increased up to 40 kg N ha^{-1} at 2 sites. We have concluded that for the cv. Cream Gold grown on siliceous sands, the high rates of fertiliser N required to maximize marketable yield and bulb size were not detrimental to quality.

Bhatia and Pandey (1991) worked on planting methods, fertility levels and spacing on seed production of Kharif onion at Haryana, India. The experiment consisted of the 2 planting methods (seed-to-seed and bulb-to-seed), three rates of NPK fertilizer application viz. 50 + 20 +10, 100 + 40 + 15 and 150 + 60 + 20 kg/ha and 3 plant spacing viz. 45.x15, 45 x 30 and 45 x 45 cm. The full doses of P and K were applied at transplanting. In both methods, N was applied in 4 equal split doses at (lie time ol seedling transplanting, 30 and 60 days after transplanting. It was observed that highest scape length (73.7), seed yield/ umbel (2.58g), 1000 seed weight (3.22 g), germination % (73.2%), seed yield per plant (20.39g) and seed yield/ha (10.27q/ha) was obtained with the 150 + 60 + 20 kg ha^{-1} NPK terti1izer treatment.

Ilin (1992) studied onion seed quality in relation to fertilization with cv. Kupusiuski Jahucar, grown From spring planted sets at Novisad, Yugoslavia. in his experiment five N levels were applied viz; 0, 80, 100, 120 and 140 kg/ha and yields were obtained 2.0, 2.19, 2.25, 2.26 and 2.35 g/flower head respectively. Germination capacity and energy were net affected by N application but depended on seasonal growing condition.

Pandey *et al.* (1992) carried out an, experiment with onion cv. Agrifound Dark Red at Jaipur, India, to investigate the effects of different levels of N viz. 0, 40, 80 and 120 kg N ha^{-1} and different plant spacing viz. 45x30 cm, 60x30 cm or 60x45 cm. N was applied split equally in to basal and top dressing. They found closer spacing and both 80 and 120 kg N/ha gave significantly higher yield than the lower fertilizers rates.

Lallan *et al.* (1993) conducted an experiment with Agrifound Dark Red onion in the rabi season at the Regional Research Station, Sinnar, India. In their experiment they used three spacings (30x30 cm, 45x30 cm and 45x45cm) and four N levels (0, 40, 80 and 120 kg N ha^{-1}). Half of the N was applied as a basal dose and the rest was applied 45 days after planting. It was found that the highest seed yields (6.64 and 6.56 q ha^{-1}) wre obtained at 30x30 cm with N at 120 kg ha^{-1} and at 30x30 cm with N at 80 kg ha^{-1}, respectively.

Ilin (1994) conducted an experiment on the effects of nitrogen nutrition to seed production of onion. En the experiment, live N rates 0, 80, 100, 120 and 140 kg ha^{-1} were used. The results are statistically analyzed. Clear seed' yield averaged 1231 kg ha^{-1}. N application increased seed yield, which were also at faced by weather condition. N at 100 kg ha^{-1} increased seed yield by 13% compared with no fertilizer (1088.5 kg/ha) and at 120 kg ha^{-1} by 17%.

Mishra (1994) in his two years trial studied the effect of nitrogen and potassium on onion seed production in calcareous soil. He stated that application of 120 kg N/ha significantly increased the number of flowering scapes, umbel size, seed yield and seed germination. K alone had no effect but in combination with N gave positive results. He also stated that applying 120 kg N + 40 kg N ha^{-1} gave the best results in terms of the number of flowering scapes, umbel size and seed yield. This combination gave the highest seed yield (499 and 555 kg ha^{-1}, respectively and germination (82% and 78% during the first and second year, respectively.

Nwadukwe and Chude (1995) observed in a field trial on onion seed production during 1988-91, under irrigation at Kadawa, Nigeria, with five N rates viz. 0, 50, 100, 150 and 200 kg ha^{-1} and four P rates viz.

0, 25, 50 and 75 kg, P ha^{-1}. They stated that the main effects of N and P and their interaction on number of umbels per original bulb, seed weight per umbel and seed yield were significant but there were no significant effects on plant stand and 1000-seed weight. They also found that application of 150 kg or 200 kg N ha^{-1} resulted in significantly higher seed yields than other N rates.

Bhonde *et al.* (1996) studied in Maharashtra, India to know the effect of frequency of irrigation and nitrogen levels on yield and quality of onion seed. They used three irrigation intervals and three rates of N fertilizer. They stated that irrigation at 10-day intervals with 80 kg N ha^{-1} in split applications gave the highest yield o quality seed of onion cv. Agrifound Light red.

Rahim *et al.* (1997) conducted an experiment at Mymensingh, Bangladesh, from November 1991 to April 1992 on the effect of nitrogen and potash on the yield of onion seed. Four nitrogen level each at 0, 25, 50 and 100 kg/ha and four K_2O level each at 0, 40, 80 and 1 60 kg ha^{-1} were used. Half of the required quantity of nitrogen were applied during the final preparation of land and the remainder of the N were applied as top dressing after 36 days of planting. They reported that the highest number of tillers/plant, number of flower stalk/plant, number of flowers/umbel, number of fruits/umbel, seed yield/plot and seed yield/ha were obtained From the plant receiving the highest N and K rates. The treatments combination (100 kg N ha^{-1} + 160 kg K_2O ha^{-1}) gave the highest seed yield 508 kg ha^{-1}.

Amjad *et al.* (1999) studied the effect of nitrogen and phosphorus on seed production of three onion cultivars dark red, Early red and Faisal

Red) at Faisalabad Pakistan. In their experiment, four nitrogen levels viz. 0, 25, 50 and 75 kg ha^{-1} and four P levels viz. 0, 15, 30 and 45 kg ha^{-1} were used. All the P and half of the N were applied at the time of sowing while the rest of N was applied as a top dressing at flowering. They found fertilizer doses had significant effect on diameter of umbel, number of flowers per umbel and seed yield, while time taken to flowering and number of flower stalks per plant have no significant response to these particular doses of fertilizer. They also found interaction between cultivars and fertilizers doses was only significant for number of flower stalks were produced in cv. Faisal Red at a fertilizer dose of N-75 kg ha^{-1} +45 kg P_20_5 ha^{-1}.

Khan *et al*. (2002) reported that various plant spacing resulted in the increased plant height, onion bulb size, weight of the bulbs, number of the bulbs per plot and yield of the bulbs. In case of different nitrogen levels, all the parameters under the study were significantly affected. However, 12 cm plant spacing with 100 kg N ha -1 gave the best results. Maximum yield of onion bulbs (22.90 and 22.82 t ha $^{-1}$) was obtained from 12 cm plant spacing with 100 kg N ha $^{-1}$, respectively.

Al-Moshileh (2002) conducted field experiments to evaluate the effect of rate and time of nitrogen application on onion cv. Texas Yellow Grano production in Al-Qassim region, Saudi Arabia during the years of 1997, 1998 and 1999. The nitrogen rates were zero, 100, 200 and 300kg ha^{-1} . This amount was applied at transplanting, 15 days later or divided in two equal doses applied 15 and 30 days after transplanting. The onion bulb yield was significantly higher with split application of nitrogen fertilizer and also with 200 kg N ha^{-1}. The leaf area and the leaf dry weight were also significantly higher with the latest nitrogen application and with highest dose of nitrogen fertilizer as compared to the earlier nitrogen application and to the lower dose of nitrogen fertilizer. No treatment interactions were detected. It was concluded that the application of 200 kg N ha^{-1} on 15 and 30 days after transplantation, should give the highest onion yield in the central region of the Kingdom of Saudi Arabia.

Hemlanaik and Hosamani (2003) conducted an experiment to know the effect of spacing and various nitrogen levels on growth and yield of kharif onion (*Allium cepa* L.) under rainfed condition of Dharwad region. Three spacing (15 x 10 cm, 15x15 cm and 15 x 20 cm) with four levels of nitrogen (N) (O,50,100 and 150 kg/ha) were tried . Among the spacing and N levels tried, narrow spacing of 15 x 10 cm with application of 150 kg N/ha was found to be the optimum in enhancing the onion yield (169.02 q/ha) and other growth and quality parameters like plant height, number of leaves, bulb length, bulb diameters and total soluble solid of the bulb. And also maximum net return and benefit:cost ratio was also found in the same treatment combination.

Aliyu *et al.* (2007) conducted an experiment in 2003/2004 and 2004/2005 dry seasons to study the effect of Nitrogen (N) and Phosphorus (P) on the growth and yield of irrigated onion in the Sudan Sananna of Nigeria. The treatments consisted of factorial combinations of four levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and three levels of phosphorus (0, 17.5 and 35 kg P ha^{-1}) laid out in split-plot design with three replications. Nitrogen was allocated to the main plots while phosphorus was assigned to the sub-plots. Results revealed that N and P as well as their interaction, significantly affected plant height, number of leaves per plant, percentage bolters, crop growth rate and individual bulb weight. However, interaction was not significant on bulb yield. Nitrogen at the rate of 150 kg N ha^{-1} gave the best results, though, statistically at par with 100 kg N ha^{-1}. 17.5 kg P ha^{-1} gave statistically similar results as 35 kg P ha^{-1}. The optimum combination from the results of this investigation was 100 kg N ha^{-1} and 17.5 kg P ha^{-1}.

May *et al.*(2007) was conducted an experiment arranged in factorial 2 x 4 x 4 x 4, respectively correspondent by cultivars (Optima and Superex), nitrogen (0; 50; 150 and 150 kg ha^{-1} of N), potassium (0; 75; 150 and 225 kg ha^{-1} of K_2O) and planting density (60; 76; 92 and 108 plants m^{-2}). The experimental design was of randomized blocks, with four replications. The fertilizers ammonium nitrate and potassium chloride were employed to provide N and K, respectively. The nitrogen and potassium application reduced to near to zero the incidence of non-comercial bulbs in both cultivars. The largest percentage of bulbs measuring 50 to 70 mm was reached with 60 plants m^{-2} and application of 150 kg ha^{-1} of N, mainly for cv. Superex. Cultivar Superex presented the largest quantity of double bulbs, with the application of 150 kg ha^{-1} of N (17% of the total bulbs produced) and plant population of 60 plants m^{-2} (22% of the total bulbs).

Ali (2009) conducted an experiment during the period from October 2003 to April 2004 to study the effect of nitrogen level and time of application on yield and quality seed production of onion (cv. Taherpuri) at Rajshahi University campus, Rajshahi, Bangladesh. Two different factors were considered in the study, factor (A): four levels of N (0,90,120,150) kg N ha^{-1} and factor (B): five times of N application viz. T1=33.3% at before planting+33.35 at 30 DAP+ 33.3% at flowering time, T2= 50% at maximum growth stage + 50% at the flowering stage, T3= 25% at before planting+ 25% at 30 DAP + 25% at maximum growth stage+ 25% at flowering time, T4= 100% at the maximum growth stage one time and T5= 1005 at the time of flowering one time. The experiment was laid out in a split plot design with three replications. the result revealed that bulb emergence, plant height, leaves, length of scape, tillers, seeded fruits, scape formation, seed yield and germination percentage were significantly influenced by different treatments. Nitrogen 150 kg $ha^{-1}$and four times N application produced more effective flowering stalks and showed better performances on seed yield and quality of onion.

It is revealed from the above review of literature that growth, yield and quality of onion seed are influenced by different levels of nitrogen.

The review of literature pertaining to the experiment which has been up heaved above revealed that Taherpuri variety of onion showed wide variation on growth, quantity and quality of seed in onion seed production in respect of planting time, plant spacing and nitrogen levels.

Chapter Three

Materials and Methods

MATERIALS AND METHODS

This chapter deals with the materials and methods that were used in carrying out the experiment.

3.1 Description of the experimental site

3.1.1 Location

Geographically the experimental field is located at 24°22′36″ N latitude and 88°38′27″ E longitude with a height of 71 ft above the sea level. The land was medium high belonging to the calcareous dark grey flood plain soil type (Gangetic Alluvial Soil Tract). The experimental area experiences sub-tropical climate under central southern part of High Ganges River Floodplain, under Agro-ecological zone-11 (AEZ-11) (FAO & UNDP, 1988).

3.2 Climate

The experimental area was situated under sub tropical climate characterized by high temperature, heavy rainfall during kharif season (April to September) and scanty rainfall associated with moderately low temperature during Rabi season (October to March). The monthly average, maximum and minimum air temperatures, relative humidity and rainfall are shown in Appendix II.

3.3 Soil

The experimental field was a medium high land with sandy loam soil texture having P^H value of 8.6, status of nitrogen, phosphorus and cation exchange capacity was medium. The characteristics of the soil of the experimental field have been presented in Appendices Ia, Ib and Ic .

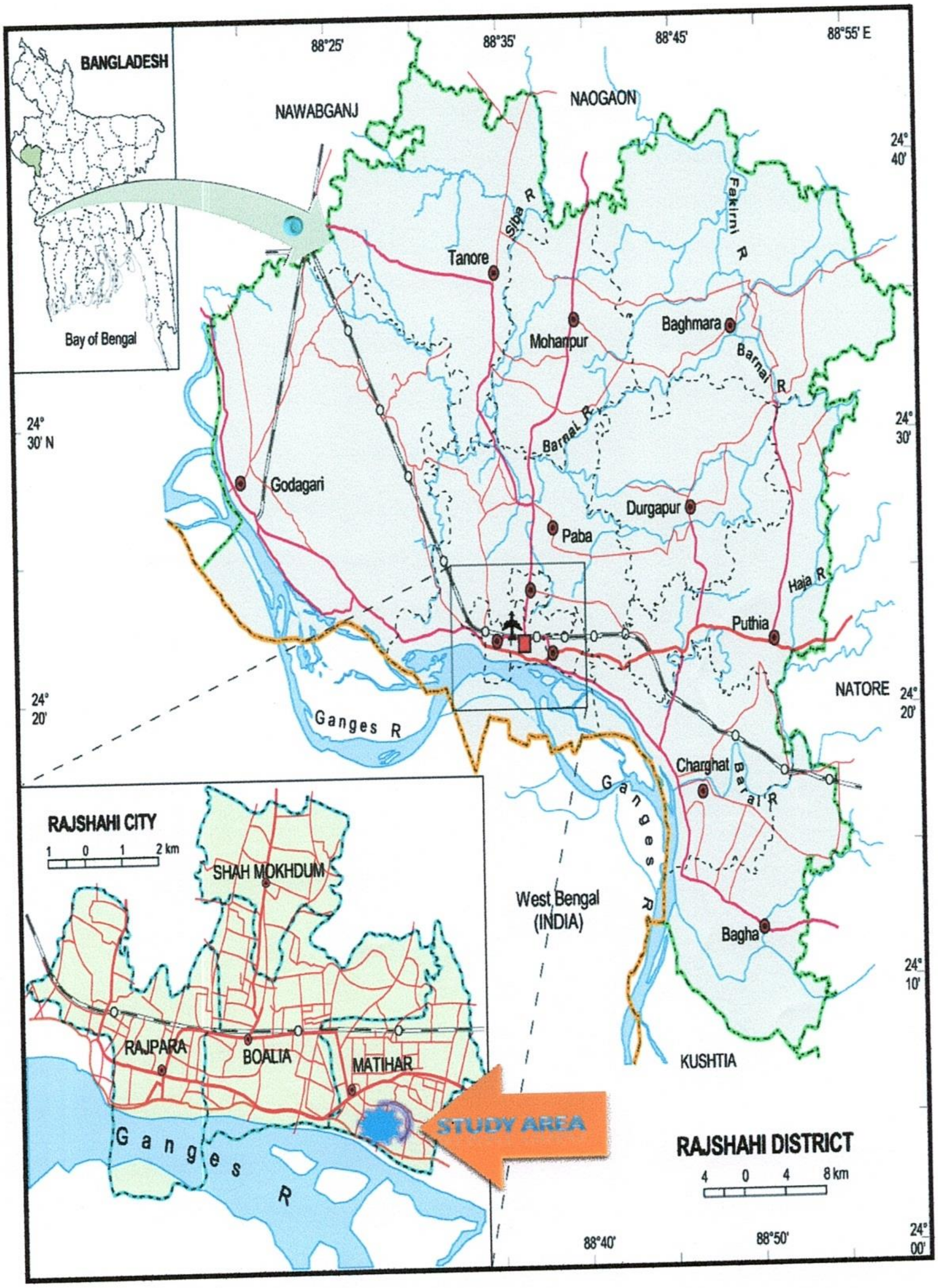

Fig. 1. Location map of the study area

3.4 Experimental material

In the research work, the onion cultivar 'Taherpuri' was used. The bulb was collected from Taherpur area of Rajshahi district. The shape of the bulb was flat, reddish brown in colour, single type (non-splited), high dry matter, high pungency and high yield.

3.5 Treatments of the experiment

The treatments of the experiments are as follows-

Factor A: Planting date - 3

1. November 05 (D_1)
2. November 25 (D_2)
3. December 15 (D_3)

Factor B: Plant spacing - 4

1. 25cm × 10cm (S_1)
2. 20cm × 15cm (S_2)
3. 25cm × 15cm (S_3)
4. 25cm × 20cm (S_4)

Factor C: Levels of nitrogen - 4

1. 0 kg/ha (N_0)
2. 100 kg/ha (N_1)
3. 150 kg/ha (N_2)
4. 200 kg/ha (N_3)

3.6 Design and layout of the experiment

The experiment was laid out in Split-Split plot Design with three replications. The planting dates were assigned in the main plots, plant spacing in the sub plot and the nitrogen level in the sub- sub plots. The total number of unit plots was 144. The size of each unit plot was 1.5 m × 1.0 m. The spaces between blocks and unit plots were 50 cm and 50 cm, respectively.

3.7 Land preparation

The land was first opened 5 October, 2008 by power tiller and it was made ready for planting bulbs on November 04, ploughing and cross ploughing with a country plough followed by laddering. During land preparation, weeds and stubbles of the previous crops were collected and removed from the field. The clods were broken into friable soil and the surface was leveled until the desired tilth was obtained.

3.8 Planting of bulbs

Medium bulbs of uniform size (8-l0g) were planted on specific dates according to the treatments of the experiment described in experimental trials. Bulbs were set upright (Novak, 1979) and at a depth of 2.5 cm (Bhardwaj *et at*., 1991). Each plot had 60, 50, 40 and 30 plants for the spacings 25 x 10, 20 x 15, 25 x 15 and 25 x 20 cm^2, respectively. Bulbs of each treatment were also planted at the border of the experiment field separately.

3.9 Manures and fertilizers application

The following fixed doses of manure and fertilizers were applied in the experimental plots (HRDP, 1995).

Manure / Fertilizers	Dose ha^{-1}	Dose $plot^{-1}$
Well decomposed cow-dung	15 ton	2.25 kg
Triple super phosphate (TSP)	247 kg	4.0 g
Muriate of potash (MP)	148 kg	2.22 g

The whole quantity of cowdung was applied immediately after opening the land. Total amount of TSP and MP were applied during the final land preparation and was thoroughly mixed with soil. Urea as per treatment was applied as the source of nitrogen and applied as top dressing in one installment after 15 days of planting.

3.10 Intercultural operations

3.10.1 Gap filling

The unsprouted bulbs were replaced by healthy plants taken from the border plants. The damaged plants were also replaced by border plants of the same treatment from the border within 7 days of planting for gap filling.

3.10.2 Weeding

Weeding was done whenever necessary to keep the crop free from weeds and to pulverize the soil. Weeding was done manually by 'Khurpi'. The common weeds were *Cynodon dactylon* L., *Cyperus rotandus* L. and *Chenopodium album* L.

3.10.3 Irrigation

Irrigation was done properly by watering can of each plot whenever necessary and care had been taken to avoid water flow from one plot to another.

3.10.4 Control of insect pests and diseases

Some plants were attacked by cut worm (*Agrotis ypsilon*) and field cricket (Brachytrypes portentosus). These insects were controlled mechanically. Rovral 50 WP (2500 ppm, HRDP, 1995) was sprayed first at 25 DAP, second at 45 DAP and third at 73 DAP at the rate of 2 g in 1 litre of water to control purple blotch disease (caused by *Alternaria porri*).

3.10.5 Staking

Staking was provided in each plot using bamboo sticks to keep the plants erect and to protect them from the damage caused by storm and strong wind.

3.11 Harvesting

The matured umbels were harvested at different dates when about 15-20% of the fruit had black seed exposed (Vander Meer and Van Bennekom, 1968). Umbels were harvested with a small portion of flowering stalk in the morning to prevent shattering of seeds. It was done in between April 9 to April 20, 2009.

3.12 Threshing, cleaning, drying and storage

Harvested onion umbels were dried on the cemented floor of Agronomy Field laboratory of the Department of Agronomy and Agricultural Extension, University of Rajshahi, Rajshahi. Umbels were ready for threshing when the capsules and small stems were brittle and broke quickly while rubbed between the hands. The seeds were threshed by beating the umbels with soft and small stick. Seeds were then cleaned by winnowing manually and dried by spreading in the open sunlight on brown paper until they reached safe moisture content (6-9%). After putting the seeds in airtight polyethylene bag these were kept in dry and cool place at room temperature for storing.

3.13 Germination test

After two months of storage, the seeds of each treatment were germinated in the laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, Rajshahi at room temperature to determine the germination percentage. The germination test was conducted by taking seeds from each treatment in petridishes provided with water soaked blotting paper as the substratum. The germinated seeds were counted.

3.14 Collection of field data

The experimental plots were observed frequently to record changes in plant characters at different stages of growth. Three sample plants were selected randomly from each plot and data were recorded and their mean values were calculated for each of the following characters:

3.14.1 Emergence of bulb set

Emergence of bulb set was counted for each replication from days after bulb planting (DAP) when 50% bulb emergence, were determined.

3.14.2 Plant height

It was measured from ground level to the tip of the longest leaf. Average plant height was determined from selected plants at 30, 45 and 60 days after panting (DAP) bulbs in centimeter.

3.14.3 Number of leaves plant^{-1}

The average number of green leaves for each treatment was noted from selected sample plants at 30, 45 and 60 days after planting (DAP) bulbs.

3.14.4 Number of tillers plant^{-1}

Total number of tillers appeared in the sample plants was counted and the average number of tillers per plant was calculated.

3.14.5 Length of scape

It was measured from ground level to the tip of the flowering stalk before harvest, and the average was recorded in centimeter from selected sample plants.

3.14.6 Number of umbels plant^{-1}

The average number of umbels per plant was recorded from randomly selected plants after completion of flowering.

3.14.7 Number of flowers umbel^{-1}

Number of flowers from 5 randomly selected umbels per plot was counted and the average number of flowers per umbel was calculated.

3.14.8 Number of seeded fruits umbel^{-1}

Average number of seeded fruits per umbel was computed from randomly selected 5 umbels, after harvesting.

3.14.9 Percentage of fruit set

It was determined by the formula:

$$\text{Percentage of fruit set} = \frac{\text{No.of seeded fruits per umbel}}{\text{No.of flowers per umbel}} \times 100$$

3.14.10 Seed weight umbel^{-1}

The average weight of seeds per umbel was determined in gram from the randomly selected 5(five) umbels.

3.14.11 Seed yield plant^{-1}

It was recorded from randomly selected 5(five) plants and was expressed in gram.

3.14.12 Seed yield ha^{-1}

It was calculated through conversion of the respective seed yield per plot, and was expressed in kilogram per ha^{-1}.

3.14.13 Data on seed quality

3.14.13.1 Thousand seed weight (g)

For each treatment thousand seeds were counted and weighed by electric balance in gram.

3.14.13.2 Germination percentage of seeds

After harvest, the seeds of each treatment were germinated in the laboratory at room temperature to determine the germination percentage. The germination test was conducted by taking 100 seeds from each treatment in petridishes provided with water soaked tissue paper as the substratum. Seeds were considered to have germinated when radical emerged about 1mm from the seed. The germinated seeds were counted and that was the germination percentage.

3.14 Statistical analysis

The collected data were analyzed statistically using Analysis of Variance technique and differences among treatment means were adjudged by Duncan's New Multiple Range Test (DMRT) as per to Gomez and Gomez (1984) with the help of MSTAT-C package. The difference between pair of means was performed by Least Significant Difference (LSD) test (Gomez and Gomez, 1984).

Chapter Four

Results

RESULTS

The results of this experiment have been presented and discussed in this chapter. The effects of different planting time, plant spacing and levels of nitrogen on the plant growth and seed yield and quality of onion have been presented in tables and figures. Results of the different parameters studied in the experiment have been presented and discussed under the following headings.

4.1 Effects of planting date

4.1.1 Days to 50% bulb set emergence

Planting date of onion bulb sets significantly influenced the days to 50% bulb emergence at 1% level of significance. The planting date December 15 showed the longest time (8.12) to emerge of 50% bulb set while the planting time November 5 showed the lowest time (6.69) to emerge of 50% bulb set (Table 1). The emergence of 50% bulb set for planting time November 25 (7.27) was statistically similar to the planting time November 5.

4.1.2 Plant height

Planting date showed significant differences in plant height, measured at different days after planting (DAP) except at 30 DAP. The tallest plants were obtained from the planting time November 5 at 30, 45 and 60 DAP respectively. Plant height increased with the advancement of plant age. At 30 DAP, the highest plant height (41.60cm) was found at the planting time November 5 but the smallest plant was observed at the planting time December 15 (31.59 cm). At 45 DAP, the longest plant (46.08cm) was obtained from the planting time November 5 but the smallest plant was observed at the planting time December 15 (35.17 cm), which was statistically identical to the plant (36.98) produced at the planting time November 25. However, the planting time November 5 had the tallest plant (54.03 cm) followed by planting time November 25 and December 15 showed the smallest (39.04 cm) plant which was identical to the plant produced at November 25 in 60 DAP (Table 1).

Table 1. Effect of planting date on bulb emergence, plant height and number of leaves plant^{-1} of onion seed crop at different days after planting (DAP)

Planting date	50% bulb emergence	Plant height (cm)			No. of leaves plant^{-1}		
		30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP
November 05(D_1)	6.69b	41.60	46.08a	54.03a	11.58a	14.69a	17.75a
November 25(D_2)	7.27b	33.74	36.98b	41.64b	9.90b	12.17b	13.81b
December 15 (D_3)	8.12a	31.59	35.17b	39.04b	9.41b	11.92b	12.63c
LS	**	NS	**	**	*	**	**
CV(%)	4.02	5.02	5.77	5.41	6.11	9.81	6.70
LSD	2.696	-	1.903	2.902	0.5017	0.2557	0.1515

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.

*= significant at 5% level of probability; ** = Significant at 1% level of probability;

NS = Not significant; LS = Levels of significance; CV=Co-efficient of variation

4.1.3 Number of leaves plant^{-1}

Number of leaves plant^{-1} was influenced significantly at 5 % level of significance at 30 DAP and 1% level of significance at 45 and 60 DAP by the planting time. At 30 DAP, the highest number of green leaves (11.58) plant^{-1} was obtained from the planting date November 5 while planting date December 15 produced the lowest number of leaves (9.41) plant^{-1} which was identical to number of leaves obtained from November 25 (Table 1).

At 45 DAP, the planting date November 5 produced the highest number of green leaves (14.69) plant^{-1} but the lowest number of leaves (11.92) plant^{-1} was found at planting date December 15 which was statistically identical to the result of November 25 (Table 1).

At 60 DAP, the highest number of green leaves (17.75) plant^{-1} was observed at the planting date November 5 but the lowest number of leaves (12.63) plant^{-1} was found at the planting date December 15(13.81) (Table 1).

4.1.4 Number of tillers plant^{-1}

The planting date had highly significant effect on the number of tillers per plant. Maximum number of tillers plant^{-1} (2.80) was produced by the planting date November 5 followed by that of the planting date November 25 (2.64). The minimum number of tillers plant^{-1} (2.37) was obtained from the planting time December 15 (Table 2).

4.1.5 Length of scape

The length of scape was influenced significantly by the planting date. Planting date November 5 produced the tallest scape (56.76cm) followed by planting time November 5 while the planting date December 15 produced the shortest scape (47.75cm) (Table 2).

Table 2. Effect of planting date on the yield contributing characters of onion seed crop

Planting date	No. of tillers plant^{-1}	Length of scape (cm)	No. of umbels plant^{-1}	No. of flowers umbel^{-1}	No. of seeded fruits umbel^{-1}	% fruit set
November 05(D_1)	2.80a	56.76a	3.29a	250.92a	152.10a	60.16a
November 25(D_2)	2.64b	51.62b	2.86b	228.68b	133.33b	58.06b
December 15 (D_3)	2.37c	47.75c	2.75c	190.63c	110.24c	57.49b
LS	*	**	**	**	**	**
CV(%)	6.80	5.73	4.64	8.77	7.34	7.21
LSD	0.07863	2.036	0.06645	6.336	7.005	0.4086

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.

*= significant at 5% level of probability; ** = Significant at 1% level of probability;

NS = Not significant; LS = Levels of significance; CV=Co-efficient of variation

4.1. 6 Number of umbels plant^{-1}

The planting date had marked influence on the number of umbels plant^{-1} at 1% level of significance. The highest number of umbels plant^{-1} (3.29) was counted in the planting date November 5 whereas the lowest (2.75) was in planting date December 15 (Table 2). The planting date November 5 showed the second performance (2.86).

4.1.7 Number of flowers umbel^{-1}

Number of flowers umbel^{-1} was significantly influenced by the planting date at 1% level of significance. The highest number of flowers umbel^{-1} (250.92) was found in the planting date November 5 followed by that of the planting date November 25 (Table 2). The lowest number of flowers umbel^{-1} (190.63) was obtained from the planting date December 15.

4.1.8 Number of seeded fruits umbel^{-1}

There was a highly significant variation among the planting date in respect of number of seeded fruits umbel^{-1}. The highest number of seeded fruits per umbel (152.10) was recorded from November 5 followed by planting date November 5 (133.33). The lowest number of seeded fruits umbel^{-1} (110.24) was produced by the planting date December 15(Table 2).

4.1.9 Percentage of fruit set

Percentage of fruit set varied significantly due to the different planting date. The highest percentage of fruit set (60.16) was counted in the planting date November 5 whereas, the lowest (57.49) was in planting date December 15 which was at par with the planting date November 5 (Table 2).

4.1.10 Seed weight umbel^{-1}

Seed weight umbel^{-1} was also found to be significant due to the different planting date. The highest seed weight (0.58g) umbel^{-1} was observed from the November 5 followed by the planting date November 25 and the lowest (0.42g) was observed from the December 15 (Table 3).

4.1.11 Seed yield plant^{-1}

Seed yield per plant varied significantly at 1% level of significance with the planting date. The highest seed yield plant^{-1} was observed in the planting date November 5 (1.62g) while the lowest (1.06g) was recorded in the planting time December 15. The planting time November 25 significantly ranked the second in seed yield plant^{-1}(1.32g) next to planting time November 5 (Table 3).

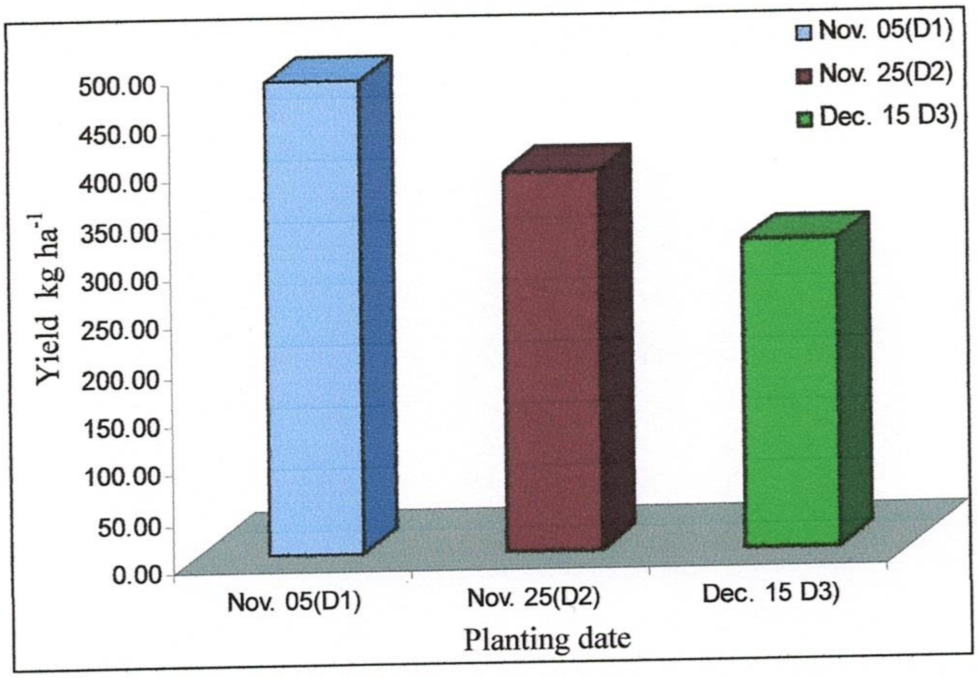

Fig. 2. Effect of planting date on the yield of onion seed crop

4.1.12 Seed yield ha^{-1}

Seed production of onion with different planting date caused marked influences in seed yield ha^{-1} at 1% level of significance. Since the seed yield per hectare was calculated on the basis of per plot yield, the seed yield per hectare exactly followed the same trend as found in seed yield per plot. Among three planting dates November 5 gave significantly the highest estimated yield ha^{-1} and this was markedly superior to the yield obtained with the planting date 25 November and the planting date December 15(Table 3 and Fig. 2).

Table 3. Effect of planting date on the yield and quality of onion seed crop

Planting date	Seed weight umbel^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield plot^{-1}(g)	Seed yield ha^{-1}(Kg)	Thousand seed weight (g)	Germination % of seed
November 05(D_1)	0.58a	1.62a	72.30a	482.46a	3.68a	80.48a
November 25(D_2)	0.47b	1.32b	58.34b	388.73b	2.99b	72.40b
December 15 (D_3)	0.42c	1.06c	47.30c	315.45c	2.69c	68.35c
LS	**	**	**	**	**	**
CV(%)	7.68	5.37	8.97	6.03	7.53	10.04
LSD	0.0093	0.06645	2.053	24.49	0.06645	0.7986

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.

*= significant at 5% level of probability; ** = Significant at 1% level of probability;

NS = Not significant; LS = Levels of significance; CV=Co-efficient of variation

4.1.13 Seed quality

4.1.13.1 Thousand seed weight

The planting date had significant effect on 1000-seed weight. The highest 1000-seed weight (3.68g) was obtained from November 5 and the lowest was (2.69g) from December 15 (Table 1).

4.1.13.2 Germination percentage of harvested seed

Germination percentages of harvested seeds were significantly influenced by the planting date. Significantly higher germination percentage (80.48) was counted in planting date November 5 over other planting time. The lowest germination percentage (65.35) was obtained from December 15 (Table 3).

4.2 Effect of plant spacing

4.2.1 Days to 50% bulb set emergence

Plant spacing differs significantly in the days to 50% bulb emergence at 1% level of significance. The plant spacing 25 x 10 cm^2 had the highest days to 50% bulb emergence (8.25) followed by the plant spacing 20 x 10 cm^2. The lowest time of the days (6.28) to 50% bulb emergence was recorded in respect of plant spacing 25 x 20cm^2 (Table 4).

4.2.2 Plant height

Plant spacing had significant effect in terms of plant height at all sampling dates in 5% level of significance. Plant height increased with the increase of plant spacing. At 30 DAP, Plants raised with the widest spacing of (25 x 20) cm^2 produced the tallest plant (36.76cm) followed (36.42cm) by the second widest spacing (25 x 15) cm^2 while the closest spacing (25 x 10) cm^2 significantly produced the shortest plant (34.16cm).

At 45 DAP, the widest plant spacing of (25 x 20) cm^2 gave the longest plant (40.86cm) followed (36.42cm) by the second widest spacing (25 x 15) cm^2 while the closest spacing (25 x 10) cm^2 significantly produced the shortest plant (37.77cm).

At 60 DAP, the longest plant (46.90cm) was found in the widest plant spacing of (25 x 20) cm^2.The second longest plant (45.16cm) was produced by the second widest spacing (25 x 15) cm^2 but the shortest plant (43.48cm) was obtained from the closest spacing (25 x 10) cm^2.

4.2.3 Number of leaves plant^{-1}

Highly significant variation was recorded in the different plant spacing in respect of green leaves plant^{-1} at all the sampling dates.

Table 4. Effect of spacing on bulb emergence, plant height and number of leaves plant^{-1} of onion seed crop at different days after planting (DAP)

Spacing	50% bulb emergence	Plant height (cm)			No. of leaves plant^{-1}		
		30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP
25cm x 10cm(S_1)	8.25a	34.16d	37.77d	43.48d	9.98b	12.07d	13.67d
20cm x 15cm(S_2)	7.75b	35.21c	39.05c	44.07c	10.23ab	12.78c	14.25c
25cm x 15cm(S_3)	7.17c	36.42b	39.95b	45.16b	10.22ab	13.08b	15.03b
25cm x 20cm(S_4)	6.28d	36.76a	40.86a	46.90a	10.76a	13.78a	15.97a
LS	**	*	*	*	*	**	**
CV(%)	4.02	5.02	5.77	5.41	6.11	9.81	6.70
LSD		0.1808	0.3808	0.3118	0.6468	0.2350	0.1214

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.

*= significant at 5% level of probability; ** = Significant at 1% level of probability;

NS = Not significant; LS = Levels of significance; CV=Co-efficient of variation

At 30 DAP, the highest number of leaves (10.76) was recorded from the plants spaced at widest spacing 25 x 20 cm^2 and the lowest (9.98) was recorded from the plants spaced, at the closest spacing 25 x 10 cm^2 (Table 4). The plants with the spacing of 20 x 15 cm^2 and 25 x 15 cm^2 produced 10.22, and 10.23 leaves plant^{-1} respectively. Number of leaves obtained from the plants with the spacing 25 x 15 cm^2 was statistically similar to that of the plants with the spacing of 20 x 15 cm^2. At 45 DAP, the widest spacing 25 x 20 cm^2 produced the highest number of green leaves (13.78) plant^{-1} but the lowest number of leaves (12.07) plant^{-1} was found at the closest spacing 25 x 10 cm^2 which was statistically identical to the result of the closest spacing 25 x 10 cm^2 (Table 4). At 60 DAP, the maximum number of green leaves (15.97) plant^{-1} was recorded from the widest spacing 25 x 20 cm^2 followed by 25 x 15 cm^2 and 20 x 15 cm^2 while the minimum number of leaves (13.67) $plant^{-1}$ was produced by closest spacing 25 x 10 cm^2 (Table 4).

4.2.4 Number of tillers $plant^{-1}$

The differences in the production of tillers $plant^{-1}$ caused by different plant spacing found to be statistically significant. Maximum number of tillers $plant^{-1}$ (2.84) was produced by the plants having the widest spacing of 25 x 20 cm^2 significantly followed by the second widest spacing of 25 x 15 cm^2 and significantly the lowest number of tillers $plant^{-1}$ (2.34) was recorded from the plants with the closest spacing of 25x 10 cm^2 (Table 5). Decreasing number of tillers $plant^{-1}$ was found from the plants having decreasing plant spacing.

4.2.5. Length of scape

The plant spacing showed highly significant influence on the length of scape at 1% level of significance. The higher length of scape (54.55 cm) was recorded in respect of the widest plant spacing 25 x 20 cm^2 but closest spacing 25x 10 cm^2 produced the lower length of scape (49.85 cm) which was statistically identical to result of the spacing 20x 15 cm^2 (Table 5).

4.2.6 Number of umbels $plant^{-1}$

Plant spacing showed significant result in respect of number of umbels $plant^{-1}$. The maximum number of umbels $plant^{-1}$(3.20) was produced by bulbs spaced at the widest spacing 25 x 20 cm^2 and the number of umbels $plant^{-1}$ was reduced with the decrease in plant spacing. Significantly the lowest number of umbels $plant^{-1}$(2.73) was recorded from the bulbs having the closest spacing 25 x 10 cm^2 (Table 2).

Table 5. Effect of spacing on the yield contributing characters of onion seed crop

Spacing	No. of tillers plant^{-1}	Length of scape (cm)	No. of umbels plant^{-1}	No. of flowers umbel^{-1}	No. of seeded fruits umbel^{-1}	% fruit set
25cm x 10cm(S_1)	2.34d	49.85c	2.73d	210.02d	119.16d	56.43d
20cm x 15cm(S_2)	2.55c	50.96c	2.84c	220.24c	126.38c	57.04c
25cm x 15cm(S_3)	2.69b	52.80b	3.09b	229.18b	136.30b	59.06b
25cm x 20cm(S_4)	2.84a	54.55a	3.20a	234.21a	145.74a	61.76a
LS	*	**	*	**	**	*
CV(%)	6.80	5.73	4.64	8.77	7.34	7.21
LSD	0.05676	1.142	0.0429	1.758	1.501	0.4193

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.

*= significant at 5% level of probability; ** = Significant at 1% level of probability;

NS = Not significant; LS = Levels of significance; CV=Co-efficient of variation

4.2.7 Number of flowers umbel^{-1}

Number of flowers umbel^{-1} differed significantly at 1% level of significance due to different plant spacing. The highest number of flowers (234.21) was recorded from the plant spacing 25 x 20 cm^2 and the lowest number of flowers (210.02) was recorded from the plant spacing 25 x 10 cm^2. The plant spacing 20 x 15 cm^2 and 25 x 15 cm^2 gave about same result (Table 5).

4.2.8 Number of seeded fruits umbel^{-1}

The number of seeded fruits umbel^{-1} was significantly affected at 1% level by different plant spacing. Maximum number of seeded fruits per umbel (145.74) was recorded from wider spacing 25 x 20 cm^2 and the number of seeded fruits decreased gradually with close spacing (Fig. 5).

The minimum number of seeded fruits umbel^{-1} (119.16) was in the closest spacing 20 x 10 cm^2.

4.1.9 Percentage of fruit set

Percentage of fruit set varied significantly due to the different planting spacing. The widest spacing 25 x 20 cm^2 produced the highest percentage of fruit set (61.76) whereas the closest spacing 25 x 10 cm^2 gave the lowest values (56.43) (Table 5).

4.2.10 Seed weight umbel^{-1}

The seed weight umbel^{-1} significantly varied at 1% level of significance due to different plant spacing. Out of four spacing, the widest spacing of 25 x 20 cm^2 gave the highest weight of seeds umbel^{-1} (0.59g) which was markedly superior to the seed weight per umbel under other spacing (Table 6). The lowest seed weight (0.39g) was obtained from the bulbs spaced at the closest spacing of 25 x 10 cm^2.

4.2.11 Seed yield plant^{-1}

The seed yield per plant was influenced significantly by the plant spacing at. A significant gradual increase in seed yield plant^{-1} was recorded with the increase in plant spacing (Table 6). The highest seed yield plant^{-1} (1.41g) was produced by the bulbs spaced at the widest spacing of 25 x 20 cm^2 significantly followed by the widest spacing 25 x 15 cm^2 and significantly the lowest seed yield plant^{-1}(1.25) was obtained from the bulbs having the closest spacing of 25 x 10 cm^2.

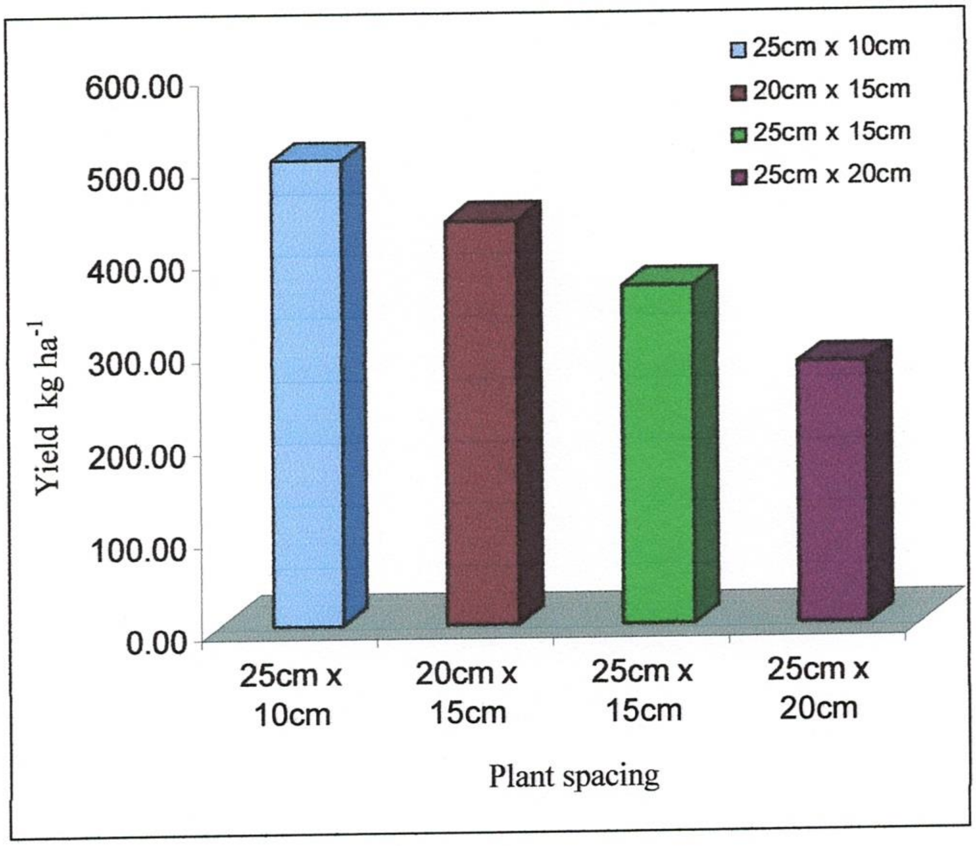

Fig. 3. Effect of plant spacing on the yield of onion seed crop

4.2.12 Seed yield ha^{-1}

Plant spacing had highly significant influence on seed yield ha^{-1} at 1% level of significance. Since the seed yield ha^{-1} was calculated on the basis of per plot yield. The estimated effective seed yield ha^{-1} was also higher in closer spacing than that of wider spacing. The bulbs having the closest spacing of 25 x 10 cm^2 showed the highest seed yield ha^{-1} (501.39 kg) followed by the spacing of 20 x 15 cm^2 (435.53 kg) while the lowest seed yield ha^{-1} (281.05 kg) was recorded from the bulbs with the widest spacing 25 x 20 cm^2 (Table 6 and Fig. 3).

Table 6. Effect of spacing on the seed yield and quality of onion seed crop

Treatment	Seed weight umbel^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (g)	Seed yield ha^{-1} (Kg)	Thousand seed weight (g)	Germination % of seed
Spacing:						
25cm x 10cm(S_1)	0.39d	1.25d	75.20a	501.39a	3.26a	73.54bc
20cm x 15cm(S_2)	0.45c	1.31c	65.34b	435.53b	3.17b	72.58c
25cm x 15cm(S_3)	0.53b	1.37b	54.59c	364.22c	3.08c	73.67b
25cm x 20cm(S_4)	0.59a	1.41a	42.09d	281.06d	2.97d	75.06a
LS	**	*	**	**	**	**
CV(%)	7.68	5.37	8.97	6.03	7.53	10.04
LSD	0.00678	0.00678	0.7649	8.310	0.04291	0.9317

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS = Levels of significance, CV=Co-efficient of variation

4.2.13 Seed quality

4.2.13.1 Thousand seed weight

Different plant spacing had significant effect on 1000-seed weight.. Thousand-seed weight was the highest (3.26 g) for the bulbs planted at closest spacing 25 x 10 cm^2 followed (3.17 g) by the spacing of 20 x 15 cm^2 whereas the lowest 1000-seed weight (2.97 g) was recorded for the bulbs planted at the widest spacing of 25 x 20 cm^2 (Table 6).

4.2.13.2 Germination percentage of harvested seed

Plant spacing had significant effect on germination percentage of harvested seed. Higher germination percentage (75.06%) was counted in plant spacing 25 x 20 cm^2 but the lowest (72.58%) was recorded in plant spacing 20 x 15 cm^2 which was statistically identical to the germination percentage (73.54%) obtained from spacing 25 x 10 cm^2 (Table 6).

4.3 Effects of nitrogen levels

4.3.1 Emergence of bulb set

Nitrogen levels had significant effect on the days to 50% bulb emergence. The days required to 50% bulb emergence were significantly early with the increasing levels of nitrogen. The highest days (8.42) required to 50% bulb emergence was obtained in control (0 kg N ha^{-1}) treatment but the lowest value (6.95) was found in N_3 treatment (200 kg N ha^{-1}).

4.3.2 Plant height

Effect of different levels of nitrogen was found significant on plant height at different days after planting (DAP). The maximum plant height was recorded in plants grown with 200 kg N ha^{-1} at 30, 45 and 60 DAP. Plant height increased with the advancement of time from 30 to 60 DAP (Table 7). At 30 DAP, the highest plant height (38.97 cm) was found in the plants which received 200 kg ha^{-1}, followed by 150 kg N ha^{-1} (37.55cm), while the lowest plant height (30.09 cm) was obtained from 0 kg N ha^{-1}. At 45 DAP, the tallest plant height (43.01 cm) was produced by 200 kg N ha^{-1}, followed by 150 kg N ha^{-1} (41.68cm), while the lowest plant height (32.83 cm) was obtained from no nitrogen application. At 60 DAP, the longest plant height (49.43 cm) was obtained from the plants which received 200 kg N ha^{-1}, followed by 150 kg N ha^{-1} (47.28 cm), while the shortest plant height (32.26 cm) was obtained from 0 kg N ha^{-1}(Table 7).

Table 7. Effect of nitrogen level on bulb emergence, plant height and number of leaves plant^{-1} of onion seed crop at different days after planting (DAP)

Nitrogen levels (Kg ha^{-1})	50% bulb emergence	Plant height (cm)			No. of leaves plant^{-1}		
		30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP
0 (N_0)	8.42a	30.09d	32.83d	37.26d	9.07c	11.18d	12.72d
100 (N_1)	7.51b	35.95c	40.12c	45.64c	10.31b	12.81c	14.61c
150 (N_2)	6.57c	37.55b	41.68b	47.28b	10.36b	13.31b	15.33b
200 (N_3)	6.95d	38.97a	43.01a	49.43a	11.45a	14.42a	16.25a
LS	*	**	**	**	**	**	**
CV(%)	5.02	0.078	0.307	0.249	1.020	0.048	0.060
LSD	0.2135	0.1742	0.3455	0.3112	0.6298	0.1366	0.1528

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS = Levels of significance, CV=Co-efficient of variation

4.3.3 Number of leaves plant^{-1}

A good foliage indicate higher growth, development and productivity of a plant. In the present study number of leaves plant^{-1} measured at 30, 45 and 60 DAP was varied significantly by different levels of nitrogen. The number of leaves plant^{-1} was increased with the passing of time irrespective of doses of nitrogen. The highest number of leaves plant^{-1} (11.45 cm), (14.2 cm) and (16.25 cm) was recorded from the plants receiving 200 kg N ha^{-1} at 30, 45 and 60 DAP, respectively. The lowest number of leaves (9.07 cm), (11.18 cm) and (12.72 cm) was found in the plants that received 0 kg N ha^{-1} at 30, 45 and 60 DAP, respectively (Table 7).

4.3.4 Number of tillers plant^{-1}

The effect of nitrogen levels on number of tillers per plant was found to be statistically significant. The maximum number of tillers (3.08) was observed in the plants of plots that received 200 kg N ha^{-1}, followed by 150 kg N ha^{-1} (2.81) and the minimum number of tillers plant^{-1} (2.02) was found from 0 kg N/ha (Table 8).

4.3.5 Length of scape

The effect of nitrogen levels on the length of scape was found to be statistically significant. The maximum length of scape (57.59 cm) was observed at the highest dose of nitrogen (200 N ha^{-1}), followed by 150 kg N ha^{-1} (53.84 cm) and the minimum length of stalk (46.28 cm) was found from the 0 kg N ha^{-1} (Table 8).

4.3.6 Number of umbels plant^{-1}

Different levels of nitrogen showed significant variations in the number of umbels per plant. Number of umbels plant^{-1} was increased with the increased levels of nitrogen. The number of umbels plant^{-1} was found to be the highest (3.34) with the application of 200 kg N ha^{-1} which was statistically identical (3.24) with 150 kg N ha^{-1} and the lowest number of umbels (2.35) plant^{-1} was recorded from the control treatment (0 kg N ha^{-1}) (Table 8).

Table 8. Effect of nitrogen level on the yield components of onion seed crop

Nitrogen levels (Kg ha^{-1})	No. of tillers $plant^{-1}$	Length of scape (cm)	No. of umbels $plant^{-1}$	No. of flowers $umbel^{-1}$	No. of seeded fruits $umbel^{-1}$	% fruit set
0 (N_0)	2.02d	46.28d	2.35c	197.75d	105.29d	53.14c
100 (N_1)	2.51c	50.46c	2.94b	218.09c	125.99c	57.57b
150 (N_2)	2.81b	53.84b	3.24a	234.13ab	143.54b	61.09a
200 (N_3)	3.08a	57.59a	3.34a	243.68a	152.75a	62.48a
LS	**	**	**	**	**	**
CV(%)	6.80	5.73	4.64	8.77	7.34	7.21
LSD	0.0441	1.210	0.02789	2.472	1.103	0.4432

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.

*= significant at 5% level of probability; ** = Significant at 1% level of probability;

NS = Not significant; LS = Levels of significance, CV=Co-efficient of variation

4.3.7 Number of flowers $umbel^{-1}$

The effect of nitrogen levels on number of flowers $umbel^{-1}$ was found to be statistically significant. The maximum number of flowers $umbel^{-1}$ (243.68) was observed in the plants that received 200 kg N ha^{-1}, followed by 150 kg N ha^{-1} (234.13), and the minimum number of flowers $umbel^{-1}$ (197.75) was found from 0 kg N ha^{-1} (Table 8).

4.3.8 Number of seeded fruits $umbel^{-1}$

The variation in number of seeded fruits $umbel^{-1}$ due to nitrogen levels was found to be significant. The number of seeded fruits $umbel^{-1}$ was found to be the highest (152.75) with the application of 200 kg N ha^{-1}, followed by

150 kg N ha^{-1} (143.54) and the lowest number of seeded fruits umbel^{-1} was recorded from the control treatment (105.29) (Table 8).

4.3.9 Percentage of fruit set

The effect of nitrogen levels on percentage of fruit set was found to be significant. The highest fruit set (62.48 %) was observed at the highest dose of nitrogen (200 kg ha^{-1}), followed by 150 kg N ha^{-1} (61.09 %), arid the minimum fruit set (53.14%) was found from 0 kg N ha^{-1} (Table 9).

4.3.10 Seed weight umbel^{-1}

The effect of the nitrogen levels on the weight of seed umbel^{-1} was found to be significant. The weight of seeds umbel^{-1} was highest (0.58 g) in the plants of the plots which received 200 Kg N ha^{-1}, followed by 150 Kg N ha^{-1} (0.53 g). The lowest weight of seeds umbel^{-1} (0.37 g) was recorded from the plot received 0 Kg N ha^{-1}(Table 9).

Table 9. Effect of nitrogen level on the seed yield and quality of onion

Nitrogen levels (Kg ha^{-1})	Seed weight umbel^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield plot^{-1}(g)	Seed yield ha^{-1}(Kg)	Thousand seed weight (g)	Germination % of seed
0 (N_0)	0.37d	0.73d	32.54d	216.53d	2.76d	66.22c
100 (N_1)	0.47c	1.38c	61.41c	409.34c	3.07c	74.79b
150 (N_2)	0.53b	1.57b	69.99b	466.94b	3.28b	76.88a
200 (N_3)	0.58a	1.65a	73.29a	489.39a	3.37a	76.96a
LS	**	**	**	**	**	**
CV(%)	7.68	5.37	8.97	6.03	7.53	10.04
LSD	0.0062	0.01972	0.7384	5.019	0.02789	1.643

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.

*= significant at 5% level of probability; ** = Significant at 1% level of probability;

NS = Not significant; LS = Levels of significance, CV=Co-efficient of variation

4.3.11 Seed yield plant^{-1}

The effect of nitrogen levels on seed yield per plant was found to be statistically significant. The highest seed yield plant^{-1}(1.65 g) was observed at the highest dose of nitrogen (200 kg ha^{-1}), followed by 150 kg N ha^{-1} (1.57 g), and the lowest seed yield plant^{-1} (0.73 g) was found from 0 kg N ha^{-1} (Table 9).

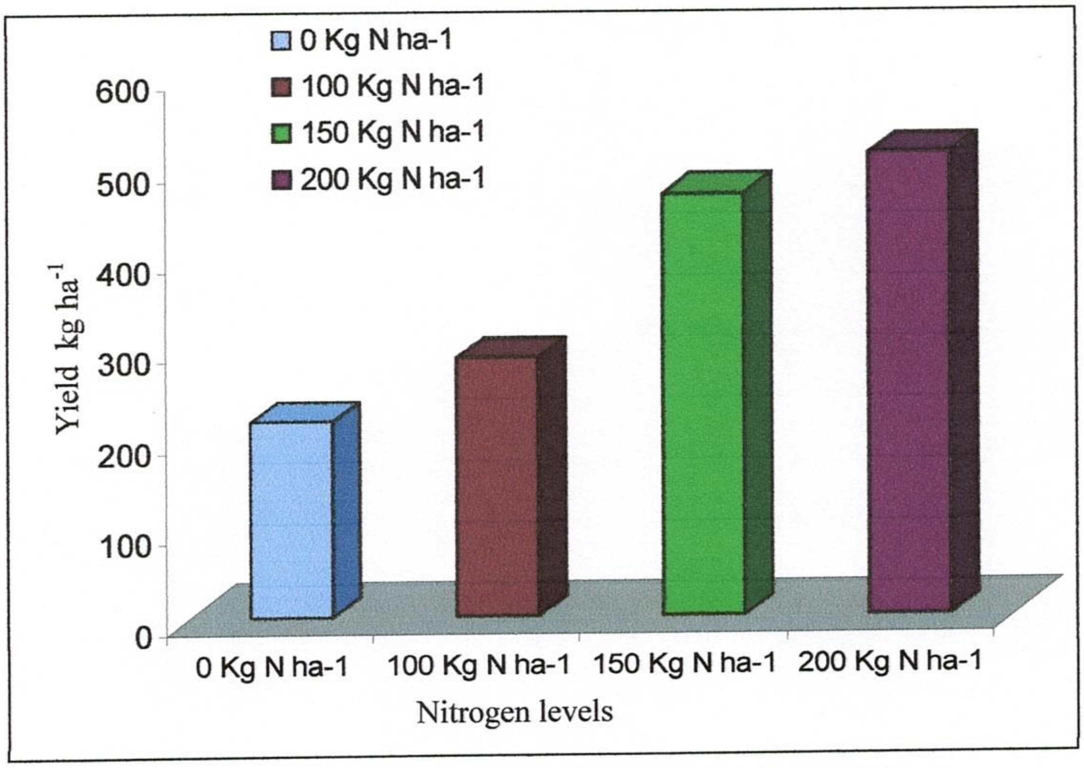

Fig. 4. Effect of nitrogen levels on seed yield of onion crop

4.3.12 Seed yields ha^{-1}

Nitrogen level had highly significant influence on seed yield per hectare at. When the yield per plot was converted into yield ha^{-1}, the highest seed yield (489.39 kg) was also obtained from the application of 200 kg N ha^{-1}, followed by 150 kg N ha^{-1} (466.94 kg) and the lowest seed yield ha^{-1} (216.53 kg) was found from 0 kg N ha^{-1} (Table 9 and Fig. 4).

4.3.13 Seed quality

4.3.13 .1 Thousand seed weight

The effect of nitrogen levels on thousand seed weight was found to be significant (Appendix IV). Seed weight was' increased gradually with the increased level of nitrogen application. The highest thousand seed weight (3.37 g) was observed at the highest dose of nitrogen (200 Kg ha^{-1}), followed by 150 kg N ha^{-1} (3.28 g) and the lowest thousand seed weight (2.76 g) was found from the control treatment (0 kg N ha^{-1}) (Table 9).

4.3.13.2 Germination percentage of seed

The effect of nitrogen levels on germination of seed was found to be statistically significant (Appendix W). The percentage of germination of seed was gradually increased with the increase in the level of nitrogen. The highest germination (76.96%) of seeds was observed from the highest dose of nitrogen (200 Kg ha^{-1}) which was statistically identical to 150 kg N ha^{-1} (76.88%) and the minimum germination (66.22%) was found from 0 kg Kg N ha^{-1} (Table 9).

4.4 Combined effect of planting date and plant spacing

4.4.1 Days to 50% bulb set emergence

The combined effect was significant in respect of days to 50% bulb set emergence. However, planting date December 15 with the closest plant spacing 25 x 10 cm^2 ($D_3 \times S_1$) took the highest days to 50% bulb set emergence (8.75) followed by the treatment combination of planting date December 15 with the second closest plant spacing of 20 x 15 cm^2 ($D_3 \times S_2$) (8.50) and the lowest days to 50% bulb set emergence was recorded from the treatment combination of planting date November 5 with the widest plant spacing 25 x 20 cm^2($D_1 \times S_4$) (Table 10).

4.4.2 Plant height

The combined effect of planting date and plant spacing varied significantly on plant height at 30 and 45 DAP but it was non-significant at 60 DAP. At 30 DAP, the treatment combination of planting date November 5 with the combination of the widest plant spacing 25 x 20 cm^2 ($D_1 \times S_4$) produced the tallest plant (42.87 cm) (Table 10). Planting date December 15 with the second closest plant spacing 25 x 10 cm^2 ($D_3 \times S_1$) produced the lowest height (30.45cm) of plants which was identical to the spacing of 20 x 15 cm^2 with the same planting time. The treatment combination of planting date November 5 with the widest plant spacing 25 x 20 cm^2 ($D_1 \times S_4$) produced the tallest plant (48.01cm) (Table 10) but Planting date December 5 with the closest plant spacing 25 x 10 cm^2 ($D_3 \times S_1$) produced the lowest height (33.82cm) of plants at 45 DAT(Table 10).

Table 10. Combined effect of planting date and spacing on bulb emergence, plant height and number of leaves plant^{-1} of onion seed crop at different days after planting (DAP)

Planting date× Spacing	50% bulb emergence	Plant height (cm)			No. of leaves plant^{-1}		
		30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP
$D_1 \times S_1$	7.75d	39.84d	44.00d	52.43	11.00	14.00d	16.25d
$D_1 \times S_2$	7.17e	41.18c	45.74c	53.09	11.84	14.42c	17.08c
$D_1 \times S_3$	6.42f	42.49b	46.58b	53.97	11.17	14.75b	18.17b
$D_1 \times S_4$	5.42g	42.87a	48.01a	56.63	12.33	15.58a	19.50a
$D_2 \times S_1$	8.25c	32.19h	35.49hi	40.28	9.69	11.08h	13.00i
$D_2 \times S_2$	7.59d	33.13g	36.27g	40.55	9.58	11.92g	13.50h
$D_2 \times S_3$	7.00e	34.43f	37.61f	42.24	10.08	12.42f	14.08f
$D_2 \times S_4$	6.25f	35.20e	38.54e	43.48	10.25	13.25e	14.67e
$D_3 \times S_1$	8.75a	30.45j	33.82j	37.72	9.25	11.11h	12.17j
$D_3 \times S_2$	8.50b	31.32j	35.13i	38.58	9.28	12.00g	11.75k
$D_3 \times S_3$	8.08c	32.35h	35.68ghi	39.27	9.42	12.08g	12.84i
$D_3 \times S_4$	7.16e	32.21h	36.03gh	40.58	9.69	12.50f	13.75g
LS	**	**	**	NS	NS	*	**
CV(%)	4.02	5.02	5.77	5.41	6.11	9.81	6.70
LSD	0.2001	0.2878	0.6062	-	-	0.2938	0.1742

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS= Level of Significance, CV=Co-efficient of variation
D_1= November 05, D_2= November 25, D_3= December 15
S_1= 25cm x 10cm, S_2=20cm x 15cm, S_3=25cm x 15cm, S_4=25cm x 20cm

4.4.3 Number of leaves plant^{-1}

The combined effect was insignificant at 30 DAP but it was significant in respect of number of leaves plant^{-1} at 45 and 60 DAP. Treatment combination of planting date November 5 with the combination of the widest plant spacing 25 x 20 cm^2 ($D_1 \times S_4$) gave the higher number of leaves (15.58) and (19.50) at 45 and 60 DAP, respectively and the lowest number of leaves (11.08) was recorded on the planting date November 25 with the closest plant spacing 25 x 10 cm^2 ($D_2 \times S_1$) at 45 DAP which was at par with the result of $D_2 \times S_1$; but at 60 DAP the lowest number of leaves (11.75) was recorded on the planting date December 15 with the second closest plant spacing 20 x 15 cm^2 ($D_3 \times S_2$) (Table 10).

4.4.4 Number of tillers plant^{-1}

The combined effect was significant in respect of number of tillers plant^{-1} at 1% level of significance. The maximum number of tillers plant^{-1} (3.12) was recorded in the planting date November 5 with the combination of the widest plant spacing 25 x 20 cm^2($D_1 \times S_4$). The lowest number of tillers plant^{-1} (2.23) was recorded from the treatment combination of planting date December 15 with the closest plant spacing 25 x 10 cm^2 ($D_3 \times S_1$) (Table 11).

4.4.5 Length of scape

The combined effect showed significant variation in respect of length of scape. It was observed that the treatment combination of planting date November 5 with the combination of the widest plant spacing 25 x 20 cm^2 ($D_1 \times S_3$) produced the tallest scape (60.80 cm) followed by the treatment combination of planting date November 25 with the combination of the second widest plant spacing 25 x 15 cm^2. The shortest flowering stalk (45.83 cm) was recorded from the treatment combination of planting date December 15 and the closest plant spacing 25 x 10 cm^2 ($D_3 \times S_1$) (Table 11).

Table 11. Combined effect of planting date and spacing on the yield components of onion seed crop

Planting date× Spacing	No. of tillers plant^{-1}	Length of scape (cm)	No. of umbels plant^{-1}	No. of flowers umbel^{-1}	No. of seeded fruits umbel^{-1}	% fruit set
$D_1 \times S_1$	2.48e	53.53cd	2.98d	238.55d	138.00e	57.50de
$D_1 \times S_2$	2.71c	55.39bc	3.15c	248.28c	145.00d	58.03d
$D_1 \times S_3$	2.90b	60.80a	3.47b	255.62b	158.48b	61.55b
$D_1 \times S_4$	3.12a	57.33b	3.55a	261.24a	166.93a	63.58a
$D_2 \times S_1$	2.31fg	50.20ef	2.65g	213.97f	120.27g	56.06f
$D_2 \times S_2$	2.60d	50.60ef	2.73f	227.93e	128.27f	56.02f
$D_2 \times S_3$	2.77c	52.03de	2.97d	236.19d	137.00e	57.90d
$D_2 \times S_4$	2.90b	53.65cd	3.09c	236.65d	147.79c	62.25b
$D_3 \times S_1$	2.23g	45.83g	2.55h	177.53j	99.19j	55.72f
$D_3 \times S_2$	2.33f	46.90g	2.66g	184.51i	105.86i	57.06e
$D_3 \times S_3$	2.41ef	49.06f	2.84e	195.73h	113.43h	57.72de
$D_3 \times S_4$	2.50e	49.20f	2.96d	204.73g	122.49g	59.46c
LS	**	*	*	*	**	*
CV(%)	6.80	5.73	4.64	8.77	7.34	7.21
LSD	0.0983	1.978	0.0743	3.044	2.606	0.7263

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS= Level of Significance, CV=Co-efficient of variation
D_1= November 05, D_2= November 25, D_3= December 15
S_1= 25cm x 10cm, S_2=20cm x 15cm, S_3=25cm x 15cm, S_4=25cm x 20cm

4.4.6 Number of umbels plant^{-1}

The combined effect significantly varied in respect of number of umbels plant^{-1}. The maximum number of umbels plant^{-1} (3.55) was obtained from the planting date November 5 with the combination of the second widest plant spacing 25 x 15 cm^2 ($D_1 \times S_4$) which was statistically identical to the

(3.47) by planting date November 5 with plant spacing of 25 x 20 cm^2 ($D_1 \times S_4$) (Table 3). The lowest number of umbels $plant^{-1}$(2.55) was observed from the treatment combination planting date December 15 and plant spacing 25 x 10 cm^2($D_3 \times S_1$).

4.4.7 Number of flowers $umbel^{-1}$

The combined effect significantly varied in respect of number of flowers $umbel^{-1}$. The differences of treatment combinations of planting date and plant spacing in respect to number of flowers $umbel^{-1}$ ranged from 177.53 to 261.24. The maximum number of flowers $umbel^{-1}$ (261.24) was produced by the treatment combination of November 5 with the widest plant spacing 25 x 20 cm^2 ($D_1 \times S_4$). This was followed by (255.62) same planting date November 5 with the second widest plant spacing 25 x 15 cm^2 ($D_1 \times S_3$), while the minimum number of flowers $umbel^{-1}$ (177.53) was counted from the treatment combination of December 15 and plant spacing 25 x 10 cm^2($D_3 \times S_1$).

4.4.8 Number of seeded fruits $umbel^{-1}$

The combined effect significantly varied in respect of number of seeded fruits $umbel^{-1}$ at 1% level of significance. The maximum number of seeded fruits $umbel^{-1}$(166.93) was obtained from the treatment combination of planting date November 5 and plant spacing 25 x 20 cm^2 ($D_1 \times S_4$) and the lowest number of seeded fruits $umbel^{-1}$ (99.19) was recorded with the treatment combination of December 15 and plant spacing 25 x 10 cm^2 ($D_3 \times S_1$) (Table 11).

4.4.9 Percentage of fruit set

Significant variation was observed in the combined effect of planting time and spacing in respect of percentage of fruit set. The highest percentage of fruit set (63.58) was counted in the planting date November 5 with the plant spacing 25 x 20 cm^2 ($D_1 \times S_4$) whereas the lowest (55.72) was in planting date December 15 with the plant spacing 25 x 10 cm^2 ($D_3 \times S_1$) (Table 11).

4.4.10 Seed weight umbel^{-1}

The combined effect of planting time and spacing was significant on seed weight umbel^{-1}. The combined effect showed a range of variation from 0.32 to 0.66 g (Table 12). The highest seed weight umbel^{-1} (0.66 g) was obtained from the planting date November 5 with the widest plant spacing 25 x 20 cm^2 ($D_1 \times S_4$). The lowest values of seed weight umbel^{-1} (0.32 g) were produced by the treatment combination of December 15 with the closest plant spacing 25 x 10 cm^2 ($D_3 \times S_4$).

4.4.11 Seed yield plant^{-1}

The combined effect showed significant variation in respect of seed yield plant^{-1}. The maximum seed yield plant^{-1} (1.68 g) were recorded from the planting date November 5 with the combination of the widest plant spacing 25 x 20 cm^2 ($D_1 \times S_4$). The lowest seed yield plant^{-1} (0.99 g) was obtained from the treatment combination of planting date December 15 and the closest plant spacing 25 x 10 cm^2 ($D_3 \times S_3$) (Table 12).

Table 12. Combined effect of planting date and spacing on the seed yield and quality of onion

Planting date×Spacing	Seed weight umbel^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield plot^{-1}(g)	Seed yield ha^{-1} (Kg)	Thousand seed weight (g)	Germination % of seed
$D_1 \times S_1$	0.49g	1.55d	93.15a	621.17a	3.83a	81.50a
$D_1 \times S_2$	0.55d	1.59c	79.50b	530.13b	3.76a	80.26a
$D_1 \times S_3$	0.61b	1.66b	66.41d	442.73d	3.68b	79.97ab
$D_1 \times S_4$	0.66a	1.68a	50.13h	335.83h	3.46c	80.19a
$D_2 \times S_1$	0.37j	1.22h	73.05c	487.00c	3.10d	71.54c
$D_2 \times S_2$	0.42i	1.28g	63.78e	424.85e	3.02e	70.61cd
$D_2 \times S_3$	0.51f	1.36f	54.11g	360.74g	2.94f	71.91c
$D_2 \times S_4$	0.58c	1.41e	42.38i	282.33i	2.89fg	75.14b
$D_3 \times S_1$	0.32k	0.99l	59.40f	396.00f	2.84g	67.56de
$D_3 \times S_2$	0.37j	1.06k	52.74g	351.63g	2.77h	66.85f
$D_3 \times S_3$	0.47h	1.09j	43.26i	289.19i	2.63i	69.12d
$D_3 \times S_4$	0.53e	1.13i	33.75j	225.00j	2.56i	69.87d
LS	**	**	**	**	**	NS
CV(%)	7.68	5.37	8.97	6.03	7.53	10.04
LSD	0.01175	0.01175	1.325	14.39	0.07432	1.614

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS= Level of Significance, CV=Co-efficient of variation
D_1= November 05, D_2= November 25, D_3= December 15
S_1= 25cm x 10cm, S_2=20cm x 15cm, S_3=25cm x 15cm, S_4=25cm x 20cm

4.4.12 Seed yield ha^{-1}

The combined effect of planting time and spacing was significant on seed yield per hectare. The maximum seed yield ha^{-1} (621.17 kg) was recorded by the planting date November 5 with closest spacing 25 x 10 cm^2 ($D_1 \times S_1$). The lowest seed yield ha^{-1} (225.00 kg) was recorded from the treatment combination of planting date December 15 and plant spacing 25 x 15 cm^2 ($D_3 \times S_3$) (Table 12).

4. 4.13 Seed quality

4.4.13.1 Thousand seed weight

The combined effect of planting time and spacing significantly varied from 2.56 to 3.83 g on 1000- seed weight. However, the highest value (3.830g) for 1000-seed weight was found from the treatment combination of the planting date November 5 with closest spacing 25 x 10 cm^2 ($D_1 \times S_1$) which was statistically identical to the values (3.76 g) of the treatment combinations of same planting date November 5 with plant spacing 20 x 15 cm^2. The lowest value (2.56 g) was recorded from the treatment combination of planting date December 15 and widest plant spacing 25 x 20 cm^2($D_3 \times S_4$) (Table 12).

4.4.13.2 Germination percentage of harvested seed

Germination percentage of seed did not varied significantly due to the combined effect of planting date and spacing. The combined effect had showed a range of variation from 66.85 to 80.50 %. The highest germination (80.50%) was recorded with the seeds produced from November 5 having plant spacing 25 x 10 cm^2 ($D_1 \times S_1$) which was statistically identical to $D_1 \times S_2$ (80.26%) and $D_1 \times S_4$ (80.19%). The lowest germination percentage (66.85 %) was counted from December 15 with plant spacing 20 x 15 cm^2 ($D_3 \times S_2$) (Table 12).

4.5 Combined effect of planting date and nitrogen levels

4.5.1 Days to 50% bulb set emergence

The combined effect was significant in respect of days to 50% bulb set emergence at 1% level of significance. However, planting date December 15 with 0 kg N ha^{-1} ($D_3 \times N_0$) required the highest days (9.83) to 50% bulb set emergence followed by (8.17) the treatment combination of planting time December 15 with 100 kg N ha^{-1} ($D_3 \times N_1$) and planting date November 25 with 100 kg N ha^{-1} ($D_3 \times N_1$) but the lowest days (6.20) to 50% bulb set emergence was recorded from the treatment combination of planting date November 5 with 150 kg N ha^{-1} ($D_1 \times 3$) (Table 13).

4.5.2 Plant height

The combined effect of planting date and nitrogen levels varied significantly on plant height at all days after planting. The tallest plant 45.49 cm, 50.31 cm and 59.18 cm was produced by the treatment combination of planting date November 5 with 200 kg N ha^{-1} ($D_1 \times N_3$) at 30 DAP, 45 DAP and 60 DAP respectively. The smallest plant 26.81 cm, 29.33 cm and 31.88 cm was produced by the combination of planting date December 15 with no nitrogen application ($D_3 \times N_0$) at 30 DAP, 45 DAP and 60 DAP respectively (Table 13).

4.5.3 Number of leaves plant^{-1}

Number of leaves per plant was insignificant at 30 and 45 DAP but significant at 60 DAP. However, the treatment combination of planting date November 5 with the combination of the 200 kg N ha^{-1} ($D_1 \times N_3$) gave the higher number of leaves (13.17), 16.08 and (19.25) at 30, 45 and 60 DAP, respectively and the lowest number of leaves was recorded from the planting date December 15 with control treatment ($D_3 \times N_0$) at all sampling dates (Table 13).

Table 13. Combined effect of planting date and nitrogen levels on bulb emergence, plant height and number of leaves plant^{-1} of onion seed crop at different days after planting (DAP)

Planting date × Nitrogen level	50% bulb emergence	Plant height (cm)			No. of leaves plant^{-1}		
		30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP
$D_1 \times N_0$	7.25cd	34.67f	37.83f	45.43e	10.17	12.92	15.83d
$D_1 \times N_1$	6.94de	42.36c	46.84c	54.78c	11.67	14.67	17.75c
$D_1 \times N_2$	6.20g	43.87b	49.35b	56.73b	11.33	15.08	18.17b
$D_1 \times N_3$	6.36fg	45.49a	50.31a	59.18a	13.17	16.08	19.25a
$D_2 \times N_0$	8.17b	28.79j	31.32i	34.48k	8.75	10.42	11.92j
$D_2 \times N_1$	7.42c	33.88g	37.79f	42.24h	9.83	11.92	13.67g
$D_2 \times N_2$	6.58f	35.49e	38.81e	43.81f	10.16	12.58	14.58f
$D_2 \times N_3$	6.92e	36.79d	39.99d	46.03d	10.86	13.75	15.08e
$D_3 \times N_0$	9.83a	26.81k	29.33j	31.88l	8.31	10.20	10.42k
$D_3 \times N_1$	8.17b	31.62i	35.73h	39.90j	9.42	11.83	12.42i
$D_3 \times N_2$	6.92de	33.29h	36.88g	41.30i	9.58	12.25	13.25h
$D_3 \times N_3$	7.58c	34.62f	38.73e	43.08g	10.33	13.42	14.42f
LS	**	**	*	**	NS	NS	**
CV(%)	4.02	5.02	5.77	5.41	6.11	9.81	6.70
LSD	0.3186	0.3017	0.5985	0.5390	-	-	0.2646

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS= Level of Significance, CV=Co-efficient of variation
D_1= November 05, D_2= November 25, D_3= December 15
N_0= 0 Kg ha^{-1}, N_1=100 Kg ha^{-1}, N_2=150 Kg ha^{-1}, N_3=200 Kg ha^{-1}

4.5.4 Number of tillers plant^{-1}

The combined effect of planting date and nitrogen levels respond significantly on number of tillers plant^{-1} at 1% level of significance. The maximum number of tillers per plant (3.35) was recorded in the combination of planting date November 5 and 200 kg N ha^{-1} ($D_1 \times N_3$) which was statistically identical to the treatment combination of $D_2 \times N_3$. The lowest number of tillers plant^{-1} (1.78) was recorded from the treatment combination of planting date December 15 with the 0 kg N ha^{-1} ($D_3 \times N_0$) (Table 14).

4.5.5 Length of scape

The combined effect showed significant variation in respect of length of scape. t was observed that the treatment combination of planting date November 5 with the combination of the 200 kg N ha^{-1} produced the tallest flowering stalk (63.62 cm) followed by the treatment combination of planting date November 5 with 150 kg N ha^{-1} (Table 14).The shortest flowering stalk (43.27 cm) was recorded from the treatment combination of planting date December 15 and 0 kg N ha^{-1}($D_3 \times N_0$).

4.5.6 Number of umbels plant^{-1}

The combined effect of planting date and nitrogen levels varied significantly in respect of number of umbels plant^{-1}. The maximum number of umbels plant^{-1} (3.63) was obtained from the planting date November 5 with the combination of 200 kg N ha^{-1}($D_1 \times N_3$) which was statistically identical to the (3.59) by planting date November 5 with 150 kg N ha^{-1} ($D_1 \times N_2$) (Table 14). The lowest number of umbels plant^{-1} (2.15) was observed from the treatment combination planting date December 15 and 0 kg N ha^{-1} ($D_3 \times N_0$).

Table 14. Combined effect of planting date and nitrogen levels on the yield components of onion

Planting date × Nitrogen level	No. of tillers $plant^{-1}$	Length of scape (cm)	No. of umbels $plant^{-1}$	No. of flowers $umbel^{-1}$	No. of seeded fruits $umbel^{-1}$	% fruit set
$D_1 \times N_0$	2.21i	50.01ef	2.65h	216.94f	115.85f	53.31fg
$D_1 \times N_1$	2.66ef	54.46c	3.33c	241.18cd	145.92d	60.42cd
$D_1 \times N_2$	2.98c	58.95b	3.54b	270.08b	169.64b	62.74b
$D_1 \times N_3$	3.35a	63.62a	3.63a	275.47a	177.01a	64.19a
$D_2 \times N_0$	2.08j	45.56h	2.25i	204.12h	109.25g	53.48f
$D_2 \times N_1$	2.50g	49.82ef	2.82g	227.15e	127.28e	55.98e
$D_2 \times N_2$	2.85d	53.82cd	3.16e	238.31d	144.65d	60.64cd
$D_2 \times N_3$	3.16b	57.28b	3.22d	245.15e	152.15c	62.13b
$D_3 \times N_0$	1.78k	43.27i	2.15j	172.18k	90.75i	52.64g
$D_3 \times N_1$	2.38h	47.10gh	2.68h	185.93j	104.8h	56.31e
$D_3 \times N_2$	2.59f	48.75fg	3.02f	193.98i	116.34f	59.90d
$D_3 \times N_3$	2.73e	51.86de	3.16e	210.41g	129.09e	61.11c
LS	**	*	*	*	**	**
CV(%)	6.80	5.73	4.64	8.77	7.34	7.21
LSD	0.0738	2.095	0.0483	4.281	1.910	0.7676

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS= Level of Significance, CV=Co-efficient of variation
D_1= November 05, D_2= November 25, D_3= December 15
N_0= 0 Kg ha^{-1}, N_1=100 Kg ha^{-1}, N_2=150 Kg ha^{-1}, N_3=200 Kg ha^{-1}

4.5.7 Number of flowers $umbel^{-1}$

Highly significant combined effect existed between planting date and nitrogen levels in respect of number of flowers $umbel^{-1}$. The maximum number of flowers per umbel (275.74) was produced by the treatment combination of planting date November 5 with 200 kg N ha^{-1}($D_1 \times N_3$).

This was followed by (270.08) same planting date November 5 with 150 kg N ha^{-1}($D_1 \times N_2$), while the minimum number of flowers umbel^{-1} (172.18) was counted from the treatment combination of December 15 and 0 kg N ha^{-1}($D_3 \times N_0$) (Table 14).

4.5.8 Number of seeded fruits umbel^{-1}

The combined effect of planting date and nitrogen levels varied significantly in respect of number of seeded fruits umbel^{-1}. The maximum number of seeded fruits umbel^{-1} (177.01) was obtained from the treatment combination of planting time November 5 and with 200 kg N ha^{-1} ($D_1 \times N_3$) which was identical to the combination of ($D_1 \times N_2$) and ($D_1 \times N_3$) and the lowest number of seeded fruits umbel^{-1} (90.75) was recorded with the treatment combination of December 15 and 0 kg N ha^{-1} ($D_3 \times N_0$) (Table 14).

4.5.9 Percentage of fruit set

There was significant variation in the combined effect of planting date and nitrogen levels in respect of percentage of fruit set at 1% level of significance. The highest percentage of fruit set (64.19) was found in the planting time November 5 with 200 kg N ha^{-1} ($D_1 \times N_3$) while the lowest (52.64) was in planting time December 15 with 0 kg N ha^{-1} ($D_3 \times N_0$). (Table 14).

4.5.10 Seed weight umbel^{-1}

The combined effect of planting date and nitrogen levels was significant on seed weight umbel^{-1} at 1% level of significance. The combined effect showed a range of variation from 0.32 to 0.62 g (Table 15). The highest seed weight umbel^{-1} (0.62 g) was observed in the planting time November 5 with 200 kg N ha^{-1} ($D_1 \times N_3$) but the lowest values of seed weight umbel^{-1} (0.32 g) were produced by the treatment combination of December 15 with control treatment (0 kg N ha^{-1}) ($D_3 \times N_0$).

4.5.11 Seed yield plant^{-1}

The combined effect of planting date and nitrogen levels showed significant variation on seed yield plant^{-1}. The highest seed yield per plant (1.97 g) was recorded in the combination of planting time November 5 with 200 kg N ha^{-1}($D_1 \times N_3$). The lowest number of seed yield plant^{-1} (0.54 g) was recorded from the treatment combination of planting time December 15 with control treatment (0 kg N ha^{-1}) ($D_3 \times N_0$) (Table 15).

4.5.12 Seed yield ha^{-1}

Seed yield ha^{-1} varied significantly due to the combination of planting date and nitrogen levels on (Appendix II). The maximum seed yield ha^{-1} (584.85 kg) was obtained from the planting date November 5 with 200 kg N ha^{-1} ($D_1 \times N_3$). The lowest seed yield ha^{-1} (157.67 kg) was recorded from the treatment combination of planting time December 15 and control treatment (0 kg N ha^{-1}) ($D_3 \times N_1$) (Table 15).

Table 15. Combined effect of planting date and nitrogen levels on the seed yield and quality of onion

Planting date × Nitrogen level	Seed weight umbel^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (g)	Seed yield ha^{-1} (Kg)	Thousand seed weight (g)	Germination % of seed
$D_1 \times N_0$	0.45e	0.93i	41.78i	278.68i	3.12e	71.69d
$D_1 \times N_1$	0.57c	1.70c	75.48c	503.18c	3.67c	82.28a
$D_1 \times N_2$	0.62b	1.89b	84.33b	563.15b	3.94b	83.75a
$D_1 \times N_3$	0.67a	1.97a	87.60a	584.85a	4.01a	84.19a
$D_2 \times N_0$	0.35g	0.73j	32.04j	213.24j	2.72h	67.07d
$D_2 \times N_1$	0.45e	1.36f	60.08f	400.33f	2.90f	72.85bc
$D_2 \times N_2$	0.51d	1.54e	68.46e	456.35e	3.12e	74.53bc
$D_2 \times N_3$	0.57c	1.64d	72.75d	485.00d	3.20d	74.76b
$D_3 \times N_0$	0.32h	0.54k	23.78k	157.67k	2.45j	59.92e
$D_3 \times N_1$	0.40f	1.09h	48.68h	324.50h	2.65i	69.21ed
$D_3 \times N_2$	0.46e	1.29g	57.20g	381.33g	2.77g	72.36d
$D_3 \times N_3$	0.51d	1.35f	59.51f	398.33f	2.89f	71.92cd
LS	**	**	**	**	**	**
CV(%)	7.68	5.37	8.97	6.03	7.53	10.04
LSD	0.0108	0.03416	0.8409	8.694	0.04831	2.845

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS= Level of Significance, CV=Co-efficient of variation
D_1= November 05, D_2= November 25, D_3= December 15
N_0= 0 Kg ha^{-1}, N_1=100 Kg ha^{-1}, N_2=150 Kg ha^{-1}, N_3=200 Kg ha^{-1}

4.5.13 Seed quality

4.5.13.1 Thousand seed weight

There was significant variation on 1000-seed weight due to the combined effect of planting date and nitrogen levels. The highest value (4.01g) for

1000-seed weight was found from the treatment combination of the planting time November 5 with 200 kg N ha^{-1} ($D_1 \times N_3$). The lowest value (2.45 g) was recorded from the treatment combination of planting time December 15 and control treatment (0 kg N ha^{-1}) ($D_3 \times N_0$) (Table 15).

4.5.13.2 Germination percentage of harvested seed

The combined effect of planting date and nitrogen level had showed a range of variation from 59.92 to 84.19 % on germination percentage of seed. The highest germination (84.19%) was recorded with the seeds produced at November 5 with 200 kg N ha^{-1} ($D_1 \times N_3$) which was identical to $D_1 \times N_1$ and $D_1 \times N_2$. The lowest germination percentage (53.89%) was counted from November 25 with control treatment (0 kg N ha^{-1}) ($D_3 \times N_0$) (Table 15).

4.6 Combined effect of plant spacing and nitrogen levels

4.6.1 Days to 50% bulb set emergence

The combined effect of plant spacing and nitrogen levels was significant in respect of days to 50% bulb set emergence. However, closest plant spacing 25 x 10 cm^2 with control treatment (0 kg N ha^{-1}) ($S_1 \times N_0$) required the highest days to 50% bulb set emergence (9.44) followed by (8.50) the treatment combination of second closest plant spacing 20 x 15 cm^2 with control treatment (0 kg N ha^{-1}) ($S_2 \times N_0$) and the lowest days (5.88) to 50% bulb set emergence was recorded from the treatment combination of widest plant spacing 25 x 20 cm^2 with highest dose of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$) (Table 16).

Table 16. Combined effect of spacing and nitrogen level on bulb emergence, plant height and number of leaves plant^{-1} of onion seed crop at different days after planting (DAP)

Spacing × Nitrogen level	50% bulb emergence	Plant height (cm)			No. of leaves plant^{-1}		
		30 DAP	45 DAP	60 DAP	30 DAP	45 DAP	60 DAP
$S_1 \times N_0$	9.44a	29.35j	31.27	36.09j	8.89	10.37	11.44
$S_1 \times N_1$	8.22c	34.31g	38.50	44.05g	10.00	11.78	13.67
$S_1 \times N_2$	7.33d	35.64f	39.79	45.43f	10.00	12.44	14.45
$S_1 \times N_3$	8.00c	37.32d	41.51	48.34c	11.04	13.67	15.11
$S_2 \times N_0$	8.78b	29.76i	32.46	36.92i	8.93	11.11	12.33
$S_2 \times N_1$	8.04c	35.42f	39.87	44.60g	10.11	12.78	14.11
$S_2 \times N_2$	6.93ef	37.08de	41.45	46.36e	10.67	13.22	14.78
$S_2 \times N_3$	7.26de	38.60c	42.41	48.41c	11.22	14.00	15.78
$S_3 \times N_0$	8.11c	30.55h	33.38	37.34i	9.33	11.33	13.11
$S_3 \times N_1$	7.56d	36.92e	40.64	46.01ef	10.33	12.89	14.78
$S_3 \times N_2$	6.33 gh	38.65c	42.31	47.51d	9.55	13.44	15.67
$S_3 \times N_3$	6.67fg	39.56b	43.48	49.78b	11.67	14.66	16.56
$S_4 \times N_0$	7.33d	30.69h	34.20	38.69h	9.15	11.89	14.00
$S_4 \times N_1$	6.22hi	37.15de	41.45	47.91cd	10.78	13.78	15.89
$S_4 \times N_2$	5.67j	38.83c	43.16	49.82b	11.22	14.11	16.44
$S_4 \times N_3$	5.88ij	40.38a	44.64	51.18a	11.89	15.33	17.56
LS	**	**	NS	**	NS	NS	NS
CV(%)	4.02	5.02	5.77	5.41	6.11	9.81	6.70
LSD	0.0987	0.3695		0.6601	-	-	-

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS= Level of Significance, CV=Co-efficient of variation
S_1= 25cm x 10cm, S_2=20cm x 15cm, S_3=25cm x 15cm, S_4=25cm x 20cm
N_0= 0 Kg ha^{-1}, N_1=100 Kg ha^{-1}, N_2=150 Kg ha^{-1}, N_3=200 Kg ha^{-1}

4.6.2 Plant height

The combined effect of plant spacing and nitrogen levels did not varied significantly on plant height at 45 DAP but it was significant at 30 and 60 DAP at 1% level of significance. At 30 DAP, the treatment combination of widest plant spacing 25 x 20 cm^2 with highest dose of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$) produced the tallest plant (40.38 cm) (Table 16). Closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) produced the lowest height of plants (29.35 cm).

At 60 DAP, the treatment combination of widest plant spacing 25 x 20 cm^2 with highest dose of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$) produced the tallest plant (51.18 cm). Closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) produced the lowest height of plants (36.09 cm) (Table 16).

4.6.3 Number of leaves plant^{-1}

The combined effect of plant spacing and nitrogen levels was insignificant at 30, 45 and 60 DAP. Treatment combination of the widest plant spacing 25 x 20 cm^2 with highest dose of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$) gave the higher number of leaves at 30, 45 and 60 DAP. The closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) produced smallest number of leaves at 30, 45 and 60 DAP (Table 16).

4.6.4 Number of tillers plant^{-1}

The combined effect of plant spacing and nitrogen levels was significant in respect of number of tillers plant^{-1}. The maximum number of tillers plant^{-1} (3.42) was recorded in the treatment combination of widest plant spacing 25 x 20 cm^2 with highest dose of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$). The lowest number of tillers plant^{-1} (1.77) was recorded from the treatment combination of closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) (0 kg N ha^{-1}) (Table 17).

4.6.5 Length of scape

The combined effect of plant spacing and nitrogen was insignificant variation in respect of length of scape. It was observed that the treatment combination of widest plant spacing 25 x 20 cm^2 and highest doses of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$) produced numerically the tallest scape (60.60 cm). The shortest scape (44.95 cm) was recorded from the treatment combination of closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) (Table 17).

4.6.6 Number of umbels plant^{-1}

The combined effect of plant spacing and nitrogen levels significantly varied in respect of number of umbels plant^{-1} at 1% level of significance. The maximum number of umbels plant^{-1} (3.58) was obtained from the combination of the widest plant spacing 25 x 20 cm^2 and highest doses of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$) which was statistically identical to the (3.48) combination of second widest plant spacing 25 x 15 cm^2 and 150 kg N ha^{-1} ($S_3 \times N_3$). The lowest number of umbels plant^{-1} (2.14) was observed from the treatment combination of closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) (Table 17).

4.6.7 Number of flowers umbel^{-1}

The combined effect of plant spacing and nitrogen levels significantly varied in respect of number of flowers umbel^{-1}. The differences of treatment combinations of plant spacing and nitrogen levels in respect to number of flowers umbel^{-1} ranged from 184.15 to 252.41.

Table 17. Combined effect of spacing and nitrogen level on the yield components of onion

Spacing × Nitrogen level	No. of tillers $plant^{-1}$	Length of scape (cm)	No. of umbels $plant^{-1}$	No. of flowers $umbel^{-1}$	No. of seeded fruits $umbel^{-1}$	% fruit set
$S_1 \times N_0$	1.77g	44.95	2.14l	184.15l	96.30k	52.25hi
$S_1 \times N_1$	2.27ef	48.54	2.69h	204.21j	113.35h	55.53g
$S_1 \times N_2$	2.55de	51.47	3.00f	219.94h	131.19f	59.44e
$S_1 \times N_3$	2.77cd	54.45	3.08e	231.76f	135.78e	58.49e
$S_2 \times N_0$	2.00fg	45.48	2.26k	192.63k	98.93j	51.39i
$S_2 \times N_1$	2.53de	49.28	2.80g	212.80i	120.1g7	56.38g
$S_2 \times N_2$	2.70cd	52.72	3.11e	233.73ef	136.97e	58.61e
$S_2 \times N_3$	2.96bc	56.36	3.21d	241.79cd	149.44c	61.76cd
$S_3 \times N_0$	2.10f	46.38	2.46j	203.72j	107.07i	52.54h
$S_3 \times N_1$	2.63cd	51.63	3.07e	225.66g	130.13f	57.46f
$S_3 \times N_2$	2.86b-d	54.26	3.36c	238.58de	149.37c	62.38c
$S_3 \times N_3$	3.18ab	58.94	3.48b	248.76ab	158.64b	63.85b
$S_4 \times N_0$	2.22f	48.30	2.53i	210.49i	118.85g	56.40g
$S_4 \times N_1$	2.62d	52.40	3.21d	229.68fg	140.32d	60.90d
$S_4 \times N_2$	3.11ab	56.90	3.48b	244.25bc	156.64b	63.94b
$S_4 \times N_3$	3.42a	60.60	3.58a	252.41a	167.13a	65.80a
LS	*	NS	**	*	*	**
CV(%)	6.80	5.73	4.64	8.77	7.34	7.21
LSD	0.3017	-	0.05916	5.244	2.339	0.9401

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS= Level of Significance, CV=Co-efficient of variation
S_1= 25cm x 10cm, S_2=20cm x 15cm, S_3=25cm x 15cm, S_4=25cm x 20cm
N_0= 0 Kg ha^{-1}, N_1=100 Kg ha^{-1}, N_2=150 Kg ha^{-1}, N_3=200 Kg ha^{-1}

The maximum number of flowers $umbel^{-1}$ (252.41) was produced by the treatment combination of the widest plant spacing 25 x 20 cm^2 and highest doses of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$) which was statistically identical to the (248.76) combination of second widest plant spacing 25 x 15 cm^2 and 150 kg N ha^{-1}, while the minimum number of flowers $umbel^{-1}$ (184.15) was counted from the treatment combination of closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) (Table 17).

4.6.8 Number of seeded fruits umbel^{-1}

The combined effect of plant spacing and nitrogen levels significantly varied in respect of number of seeded fruits umbel^{-1} at 1% level of significance. The maximum number of seeded fruits umbel^{-1} (167.13) was obtained from the treatment combination of the widest plant spacing 25 x 20 cm^2 and highest doses of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$) and the lowest number of seeded fruits umbel^{-1} (96.30) was recorded closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) (Table 17).

4.6.9 Percentage of fruit set

Significant variation was observed in the combined effect of plant spacing and nitrogen levels in respect of percentage of fruit set. The highest percentage of fruit set (65.80) was counted in the widest plant spacing 25 x 20 cm^2 and highest doses of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$) which was statistically identical to the (63.94) combination of widest plant spacing 25 x 20 cm^2 and 150 kg N ha^{-1} whereas, the lowest (52.25) was in closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) (Table 17).

4.6.10 Seed weight umbel^{-1}

The combined effect of plant spacing and nitrogen levels was significant on seed weight umbel^{-1}. The highest seed weight umbel^{-1} (0.69 g) was obtained from the widest plant spacing 25 x 20 cm^2 and highest doses of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$). The lowest values of seed weight umbel^{-1} (0.31 g) were produced by the treatment combination of closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) (Table 18).

4.6.11 Seed yield plant^{-1}

The combined effect of plant spacing and nitrogen levels showed significant variation in respect of seed yield plant^{-1}. The maximum seed yield plant^{-1} (1.76 g) was recorded from the combination of the widest plant spacing of 25 x 20 cm^2 with highest doses of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_3$). The lowest number of seed yield plant^{-1} (0.70 g) was recorded from the treatment combination of closest plant spacing 25 x 10 cm^2 with control treatment ($S_1 \times N_0$) (Table 18).

4.6.12 Seed yield ha^{-1}

The combined effect of plant spacing and nitrogen levels was significant on seed yield per hectare. The maximum seed yield ha^{-1}(617.33 kg) was recorded by planting the closest plant spacing 25 x 10 cm^2 with highest doses of nitrogen (200 kg N ha^{-1}) ($S_1 \times N_3$). The lowest seed yield ha^{-1} (155.53 kg) was recorded from the treatment combination of widest plant spacing 25 x 20 cm^2 with control treatment ($S_4 \times N_0$) (Table 18).

Table 18. Combined effect of spacing and nitrogen level on the seed yield and quality of onion

Spacing × Nitrogen level	Seed weight umbel^{-1} (g)	Seed yield plant^{-1} (g)	Seed yield plot^{-1} (g)	Seed yield ha^{-1} (Kg)	Thousand seed weight (g)	Germination % of seed
$S_1 \times N_0$	0.31n	0.70j	41.81j	278.67j	2.87h	64.61ef
$S_1 \times N_1$	0.37l	1.30h	78.00d	520.00d	3.25de	76.02ab
$S_1 \times N_2$	0.42j	1.47e	88.40b	589.56b	3.41b	76.55ab
$S_1 \times N_3$	0.47h	1.54d	92.55a	617.33a	3.49a	76.96ab
$S_2 \times N_0$	0.34m	0.71j	35.54k	236.73k	2.82hi	65.43e
$S_2 \times N_1$	0.43j	1.36g	67.83e	452.20e	3.16f	73.04c
$S_2 \times N_2$	0.48h	1.55d	77.49d	516.60d	3.32c	75.83ab
$S_2 \times N_3$	0.54f	1.61c	80.49c	536.60c	3.39b	76.00ab
$S_3 \times N_0$	0.40k	0.74j	29.48l	195.38l	2.72j	66.88g
$S_3 \times N_1$	0.51g	1.43f	56.81g	378.70g	3.09g	74.32b
$S_3 \times N_2$	0.57e	1.62c	64.68f	431.17f	3.19ef	76.82a
$S_3 \times N_3$	0.62c	1.69b	67.41e	451.63e	3.33c	76.64a
$S_4 \times N_0$	0.45i	0.78i	23.30m	155.33m	2.63k	67.96d
$S_4 \times N_1$	0.59d	1.44ef	43.01j	286.44j	2.80i	75.76ab
$S_4 \times N_2$	0.64b	1.65c	49.40i	330.44i	3.18f	78.32a
$S_4 \times N_3$	0.69a	1.76a	52.64h	352.00h	3.26d	78.24a
LS	*	**	**	**	*	*
CV(%)	7.68	5.37	8.97	6.03	7.53	10.04
LSD	0.01323		1.030	10.45	0.0591	3.485

In each column, figures having similar letters or without letters do not differ significantly, where as figures bearing dissimilar letters differ significantly as per DMRT.
*= significant at 5% level of probability; ** = Significant at 1% level of probability;
NS = Not significant; LS= Level of Significance, CV=Co-efficient of variation
S_1= 25cm x 10cm, S_2=20cm x 15cm, S_3=25cm x 15cm, S_4=25cm x 20cm
N_0= 0 Kg ha^{-1}, N_1=100 Kg ha^{-1}, N_2=150 Kg ha^{-1}, N_3=200 Kg ha^{-1}

4.6.13 Seed quality

4.6.13.1 Thousand seed weight

The combined effect of plant spacing and nitrogen levels significantly varied from 2.63 to 3.48 g on 1000- seed weight. However, the highest value (3.49g) for 1000-seed weight was found from the treatment combination of the closest spacing 25 x 10 cm^2 with highest doses of nitrogen (200 kg N ha^{-1}) ($S_1 \times N_3$). The lowest value (2.63 g) was recorded from the treatment combination of widest plant spacing 25 x 20 cm^2 with control treatment ($S_4 \times N_0$) (Table 18).

4.6.13.2 Germination percentage of harvested seed

Germination percentage of seed varied significantly due to the combined effect of plant spacing and nitrogen levels. The highest germination (78.32%) was recorded with the seeds produced from plant spacing of 25 x 20 cm^2 with highest doses of nitrogen (200 kg N ha^{-1}) ($S_4 \times N_2$) which was statistically identical to the combination of ($S_4 \times N_3$) (78.24). The lowest germination percentage (65.43%) was counted from plant spacing of 20 x 15 cm^2 with 0 kg N ha^{-1}($S_2 \times N_0$) (Table 18).

Chapter Five

Discussion

DISCUSSION

This chapter deals with the discussion of results of the experiment with relation to crop growth, yield contributing characters, yield and seed quality of onion as influenced by different planting date, plant spacing and levels of nitrogen.

Planting time of onion bulb sets significantly influenced the days to 50% bulb emergence. The planting date December 15 showed the longest time to emerge of 50% bulb set while the planting time November 5 showed the lowest time to emerge of 50% bulb set. November 5 planted bulbs emerged quickly than other planted bulbs. It was possibly due to when bulbs were planted they experienced optimum temperature from the soil environment. This finding is in agreement with the finding of Jun *et al.* (1996). The closest plant spacing 25 x 10 cm^2 had the highest days to 50% bulb emergence but the lowest days to 50% bulb emergence was recorded in respect of wider plant spacing 25 x 20cm^2. The days required to 50% bulb emergence were significantly early with the increasing levels of nitrogen. The highest days required to 50% bulb emergence was obtained in control treatment. The lowest value was found in N_3 treatment.

The tallest plants were obtained from the planting time November 5. Plant height increased with the advancement of plant age. The longest plant was obtained from the planting time November 5 but the smallest plant was observed at the planting time December 15 at all sampling dates. Early planted plants received longer cool period that possibly enhanced meristemetic elongation of plant as a result good plant height was obtained. Similar result was reported by Akola, India Mathankar *et al.* (1990). Plant height increased with the increase of plant spacing. Plants raised with the widest spacing produced the tallest plant while the closest spacing significantly produced the shortest plant. Plant heights increased with the advancement of time from 30 to 60 DAP. The maximum plant height was recorded in plants grown with 200 kg N/ha. The higher levels of nitrogen increased the vegetative growth of onion plant, which might be the cause of higher plant height. The increased plant height at the highest level of nitrogen was probably due to the availability of more nutrients, which helped, in maximum vegetative growth of onion plant. This result is in agreement with the results of Ali (2009), Nandpuri *et al.* (1968), who reported taller plants from higher dose of nitrogen. Malachowski (1975), Chakrabarti *et al.* (1980) and Bhardwaj *et al.* (1991) also reported similar results.

The highest number of green leaves per plant was obtained from the planting time November 5 while planting time December 15 produced the lowest number of leaves per plant at all harvesting. The difference in the number of green leaves per plant may be due to hormonal effect when enjoyed very cold period November 5. The highest number of leaves was recorded from the plants spaced at widest and the lowest was recorded from the plants spaced, at the closest spacing. Number of leaves per plant increased with the decrease in plant density. The result may appear due to less competition among plants of wider spacing for space, moisture, nutrients and light resulted in increase in number of leaves per plant. The results support the reports made by some previous workers (Bosu, 1999 and Singh and Sachan, 1999[b]). A good foliage indicate higher growth, development and productivity of a plant. The number of leaves per plant was increased with the passing of time irrespective of doses of nitrogen.

The highest number of leaves per plant was recorded from the plants receiving 200 kg N ha^{-1} at all sampling dates. The lowest number of leaves was found in the plants that received 0 kg ha^{-1}. The above result indicated that the increasing dose of nitrogen progressively and significantly increased the number of leaves per plant. As the higher dose of nitrogen increased the vegetative growth of onion plant which also helped to increase the number of leaves per plant. The results of this experiment are in accordance with the findings of Ali (2009) and Levy *et al.* (1978) who reported to have increased number of leaves per plant with increasing levels of nitrogen. Bokshi *et al.* (1989) also reported similar results.

Maximum number of tillers per plant was produced by the planting time November 5 followed by that of the planting time November 25. Due to optimum planting time on Nov 05 the planted bulbs took shorter time to bolting and shortly completed their optimum growth stages and enhanced to produce earlier tiller as well as flower, there fore the inner small bulbs also came out as tiller, that is why more flower stalks were produced (Brewster,1994). Similar result was reported by Nehra *et al.* (1989). Maximum number of tillers per plant was produced by the plants having the widest spacing. Decreasing number of tillers per plants was found from the plants having decreasing plant spacing. This might be due to comparatively higher competition of plants for nutrient, light and moisture at higher plant density which was also reported by Begum *et al.* (1995). Due to the higher dose of nitrogen the vegetative growth of onion plant was increased which helped to increase the number of tillers per plant. Ali (2009) and Rahim *et al.* (1997) also found higher number of tillers per plant from the plant receiving the higher nitrogen rates.

Due to optimum planting time on Nov 05 the planted bulbs took shorter time to bolting and shortly completed their optimum growth stages and enhanced to produce earlier tiller as well as flower, there fore the inner small bulbs also came out as tiller, that is why more flower stalks were produced (Brewster,1994). The result agrees with the finding of Farghali (1995). He found wide differences among planting time on flowering stalk length. The result indicated that the higher length of flowering stalk was recorded in respect of the widest plant spacing but the closest spacing produced the lower length of flowering stalk. This might be due to availability of more space, nutrient, water and light. The length of flowering stalk was increased with the increasing nitrogen levels. These results are in agreement with the results of Ali (2009) and Bhatia and Pandey (1991).

The highest number of umbels per plant was counted in the planting time November 5 whereas the lowest was in planting time December 15. This finding is in agreement with the finding of Farghali (1995). He reported that number of umbels per plant increased in early planting. Plant spacing showed significant result in respect of number of umbels per plant. The maximum number of umbels per plant was produced by bulbs spaced at the widest spacing and the number of umbels per plant was reduced with the decrease in plant spacing. Significantly the lowest number of umbels per plant was recorded from the bulbs having the closest spacing. Decreasing number of umbels per plant with the decrease in plant spacing was also observed by previous workers (Singh *et al.*, 1974; Nehra *et al.*, 1988; Bosu, 1999). This might be due to non availability of more space and resources such as nutrients, water and light. Number of umbels per plant was increased with the increased levels of nitrogen. Similar results were reported by Bokshi *et al.* (1989), Nwadukwe and Chude (1995) and Rahim *et al.* (1997). As the higher dose of nitrogen improved the development process of onion which led to higher number of umbels per plant.

Higher number of flowers, obtained from early planting at November 5.This might be due to large umbel diameter produced by them. This result is similar to the reported values of Islam and Mondal (2004) and Rizk *et al.* (1996). Number of flowers per umbel differed significantly. The highest number of flowers was recorded from the plant wider spacing and the lowest number of flowers was recorded from the plant closest spacing. Results showed that the maximum number of flowers per umbel was observed in the plants that received highest doses of nitrogen and the minimum number of flowers per umbel was found from control treatment. The increased levels of nitrogen enhanced the growth and uniform development of onion plants that might have influenced on the production of the higher number of flowers per umbel. Bokshi *et al.* (1989), Mishra (1994), Rahim *et al.* (1997) and Ali (2009) also reported similar results.

The highest number of seeded fruits per umbel in the planting time November 5 was due to reason that this planting time produced larger umbels. Similar result was reported by Farghali (1995). The results revealed that maximum number of seeded fruits per umbel was recorded from wider spacing and the number of seeded fruits decreased gradually with close spacing. The minimum number of seeded fruits per umbel was in the closest spacing.The result agrees with the report of Begum *et al.*

(1995). Higher nitrogen dose produced the higher number of fruits per umbel and the lowest number of seeded fruits per umbel was recorded from the control treatment. Similar results were reported by Bokshi *et al.* (1989), Rahim *et al.* (1997) and Ali (2009).

The highest percentage of fruit set was counted in the planting time November 5 whereas the lowest was in planting time December 15. The widest spacing produced the highest percentage of fruit set whereas the closest spacing gave the lowest values. The highest fruit set was observed at the highest dose of nitrogen, and the minimum fruit set was found from control treatment.

The highest seed weight per umbel was observed from the November 5 followed by the planting time November 25 and the lowest was observed from the December 15. The highest value for November 5 was due to larger size of umbel. Nehar *et al.* (1989) found wide differences among planting time for this trait. The widest spacing gave the highest weight of seeds per umbel but the lowest seed weight was obtained from the bulbs spaced at the closest spacing. Weight of seed per umbel increased with the increase in plant spacing. This is attributed to decreased competition for nutrients and moisture at wider spacing. Similar inference was drawn by Singh *et al.* (1990) who observed higher seed weight per umbel from wider spacing. The weight of seeds per umbel was highest in the plants of the plots which received higher doses of nitrogen, and the lowest weight of seeds per umbel was recorded from the plot received no nitrogen. Higher dose of nitrogen increased the vegetative growth of onion plant, which helped to increase the number of tillers per plant, number of seeds per umbel and thousand seed weight which might be the cause of higher weight of seeds per umbel. Bhardway *et al.*, Bhatia and Pandey (1991) and Ali (20090 also found similar results.

The planting time November 5 significantly ranked the first in seed yield per plant while the lowest was recorded in the planting time December 15. The 1st and 2nd planting time showed about same result for seed yield per plant and the last planting time showed less seed yield per plant due to lower number of tillers/plant, number of flowers/umbel, number of seeded fruits/umbel produced by this planting time. Thompson(1939) mentioned in his note that sometimes blossoming of flowering may stop even after the initiation of flower primordia due to high temperature in case of late planting. This favourable condition might perhaps led to higher percentage of seed per umbel, resulting in higher seed yield and seed quality. Similar observation was published by Akola, India, Mathankar *et al.* (1990), Krishna Veni *et al.* (1990) and Nehra *et al.* (1989). A significant gradual increase in seed yield per plant was recorded with the increase in plant spacing. The highest seed yield per plant was produced by the bulbs spaced at the widest spacing and significantly the lowest seed yield per plant was obtained from the bulbs having the closest spacing. Increasing yield might be due to availability of more space, moisture, nutrient and light at wider plant spacing. Several authors (Decampose *et al.*, 1968; Khandalwal and Maiti, 1971; Singh *et al.*, 1974; Singh and Rathore, 1977; Lal *et al.*, 1987; Nehra *et al.*, 1988; cuocoio and Barbieri, 1988; Singh *et al.*, 1990; Bhardwaj, 1991; Singh and Singh, 1991; Raijadhav *et al.*, 1992; Singh *et al.*, 1998; Singh and Sachan, 1999[a]; Singh and Sachan, 1999[b] and Kanwar *et al.*, 2000) also published a supportive results. The highest seed yield per plant was observed at the highest dose of nitrogen and the lowest seed yield per plant was found from 0 kg N/ha. The higher dose of nitrogen increased the vegetative growth of onion plant which might have helped to increase the number of tillers per plant, number flowers per umbel, number of seeded fruits per umbel and thousand seed weight that resulted higher seed yield per hill. This result was supported by the findings of Rahim *et al*. (1997) and Ali (2009).

The planting time November 5 produced the highest yield per plot. This finding confirms the result of previous workers Roy (1994), Bhonde *et al*. (1991), Singh and Singh (1984) and Rathore *et al*. (1975). The seed yield per plot in closer spacing was maximum in spite of minimum seed yield per plant due to maximum number of plant population. The highest seed yield per plot was obtained from the bulbs with the closest spacing but the lowest from the bulbs having the wider spacing. The highest seed yield per unit area was associated with the closest spacing due to accommodation of maximum number of plants. This result supports the findings of others (Jones and Emsweller, 1939; Jones and Mann, 1963; Decampose *et al*., 1968; Singh *et al*., 1976; Singh and Rathore, 1977; Singh and Singh 1984; Samaik *et al*., 1985; Diazarguelles *et al*., 1986; Cuocolo and Barbieri, 1988; Bhonde *et al*., 1989; Singh *et al*., 1990; Bhaardwaj, 1991; Pandey *et al*., 1992; Dadhania and Gajipara, 1998; Ali *et al*., 1998; Singh and Sachan, 1999a; Singh and Sachan, 1999; Kanwar *et al*., 2000). The highest dose of nitrogen (200 kg N ha^{-1}) gave the highest seed yield per plot and the lowest seed yield per plot was obtained from 0 kg N/ha (N0).

Seed production of onion with different planting time caused marked influences in seed yield per hectare. Since the seed yield per hectare was calculated on the basis of per plot yield, the seed yield per hectare exactly followed the same trend as found in seed yield per plot. Among three planting times November 5 gave significantly the highest estimated yield per hectare and this was markedly superior to the yield obtained with the planting time 25 November and the planting time December 15. The results are in agreement with Nehra *et al.* (1992), Bhonde *et al.* (1991), Gill and Singh (1989), Deshmukh and Kali (1987) and Lal *et al.* (1982).

Since the seed yield per hectare was calculated on the basis of per plot yield. The estimated effective seed yield per hectare was also higher in closer spacing than that of wider spacing. The bulbs having the closest spacing showed the highest seed yield per hectare while the lowest seed yield per hectare was recorded from the bulbs with the widest spacing. The highest seed yield per hectare was directly related to the highest plant population per hectare. Although the seed yield per plant was maximum in wider spacing, larger number of plant population compensated this yield. This result is similar to the findings of others (Jones and Emsweller, 1939; Jones and Mann, 1963; Decampose, *et al.*, 1968; Singh *et al.*, 1976; Singh and Rathore, 1977; Singh and singh, 1984; Samaik *et al.*, 1985; Diazarguelles *et al.*, 1986; Cuocplo and Barbieri, 1988; Bhonde *et al.*, 1989; Singh *et al.*; 1990; Bhardwaj, 1991; Pandey *et al.*, 1992; Dadhania and Gajipara, 1998; Ali *et al.*, 1998; Singh and Sachan, 1999a; Singh and Sachan, 1999[b] and Kanwar *et al.*, 2000). The highest seed yield per hectare was also obtained from the application of 200 kg N ha^{-1} and the lowest seed yield per hectare was found from 0 kg N ha^{-1} (N0). This result was almost similar to the findings of Bokshi *et al.* (1989) and Rahim *et al.* (1997), who observed the highest yield from the higher nitrogen levels. Bhonde *et al.* (1989); Pandey *et al.* (1992); and Bhatia and Pandey (1991) also found similar results. As the higher dose of nitrogen increased the vegetative growth of onion plant which might have helped to increase the number of tillers per plant, number of flowers per umbel, number of seeded fruits per umbel and thousand seed weight that resulted higher seed yield per hectare.

The results showed that the highest 1000-seed weight was obtained from November 5 and the lowest was from December 15. Decrease in 1000-seed weight in late planting time might be due to reduced crop duration and poor seed development. Similar result was reported by Jun *et al.* (1996), Farghali (1995) and Alam (1995). Thousand-seed weight was the highest for the bulbs planted at closest spacing whereas the lowest was recorded for the bulbs planted at the widest spacing. The trend of 1000-seed weight was about same for all the plant spacing. This might be due to lower availability of nutrient and water for the plants of all plant spacing. The results support the reports made by Amiroddin *et al.* (1988). Seed weight was increased gradually with the increased level of nitrogen application. The highest thousand seed weight was observed at the highest dose of nitrogen and the lowest one was found from the control treatment. Increasing levels of nitrogen increased the thousand seed weight of onion. Bhatia and Pandey (1991) also found similar results.

Significantly higher germination percentage was counted in planting time November 5 over other planting time. The lowest germination percentage was obtained from December 15. Higher percentage of seed germination observed from early planting time might be due to favourable climatic condition during seed development and maturity. The result is in agreement with Alam (1995) and Roy (1994). Higher germination percentage was counted in plant closest spacing and the lowest was recorded in plant widest spacing. Similar result was reported by Amiroddin *et al*., (1988) and Singh and Sachan, (1999a).

They reported that there was no significant effect on germination percentage by the plant spacing. The percentage of germination of seed was gradually increased with the increase in the level of nitrogen. The highest germination of seeds was observed from the highest dose of nitrogen and the minimum germination was found from the control treatment. Higher doses of nitrogen gave the higher germination percentage. Bhatia and pandey (1991) and Bokshi *et al*. (1989) also found similar results.

From the results of the study, the following inference could be drawn:

1. Planting date significantly influenced the growth, yield contributing characters and yield of onion seed crop. November 5 planting gave the highest seed yield and the seed yield was reduced as the planting time was delayed until December 15.
2. Plant spacing greatly influenced the yield and quality of onion seed. Planting bulbs with closer spacing gave the highest seed yield per unit area whereas bulbs with wider spacing produced the highest seed weight per plant.
3. Higher nitrogen level (200 Kg N ha^{-1}) gave higher growth and seed yield of onion.
4. The yield of onion seed crop was also significantly affected by the interaction of planting time and spacing, planting date and nitrogen levels and plant spacing and nitrogen levels.

Considering the limitations of the present study the following points should be taken under consideration before drawing any final recommendation.

i. Further investigation needs to be done using planting time earlier than November 5 to optimize planting date.

ii. Further experiments may be suggested to test the efficacy of different plant spacing and levels of nitrogen higher than present ones.

iii. Further investigation needs to be done under different agro-ecological climate of Bangladesh of the present result.

iv. An economic analysis should also be incorporated for achieving this purpose.

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Appendices

APPENDICES

Appendix - Ia: Morphological characteristics of the soil

Constituent	Characteristics
1. Location	Agronomy Field Laboratory, western side of the Department of Agronomy and Agricultural Extension ,Rajshahi University.
2. Land type	Medium high land
3. General soil type	Non calcareous dark grey soil
4. Agro-ecological zone (AEZ)	AEZ-11: High Ganges River flood plain
5. Topography	Fairly level
6. Soil color	Dark grey
7. Drainage	Well drainage
8. Soil series	Gopalpur series

Appendix- Ib: Physical properties of the initial soil (0-15cm depth)

Constituent	Results*
Particle size analysis	
Sand (%) (0.0-0.02mm)	60
Silt (%) (0.02-0.002mm)	25
Clay (%) (<0.002mm)	15
Soil texture class	Sandy loam

* = Result obtained from the mechanical analysis of the initial soil sample was done in the Soil Resource Development Institute, Regional Research Station, Shampur, Rajshahi.

Appendices

Appendix- Ic: Chemical composition of the initial soil (0-15cm depth)

Constituent	Results*
pH	7.8
Organic matter (%)	0.56
Total nitrogen (%)	0.06
Exchange able potassium (Me 100g soil-1)	0.18
Phosphorus (microgram/gram soil)	12.05
Cupper (microgram/gram soil)	4.70
Boron (microgram/gram soil)	
Zinc (microgram/gram soil)	0.65

* = Results obtained from the mechanical analysis of the initial soil sample was done in the Soil Resource Development Institute, Regional Research Station, Shyampur, Rajshahi.

Appendix- II: Monthly rainfall (mm), average air temperature, relative humidity (%) during the study period October, 2008, to April,2009 at Agronomy Field Laboratory, Rajshahi University Campus .

Month	**Year**	**Air tem erature °C**		**Relative Humidity %**	**Rainfall (mm)**
		Minimum	**Maximum**		
October	2008	22.6	31.8	84	121.0
November	2008	16.5	29.6	79	
December	2008	15.1	25.1	86	
January	2009	21.9	10.0	80	
February	2009	28.3	13.4	70	2.2
March	2009	35.5	20.2	61	2.4
April	2009	37.6	25.2	65	2.5