EFFECT OF SPACING AND FERTILIZER ON THE GROWTH AND YIELD OF ONION

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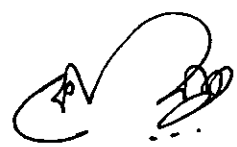

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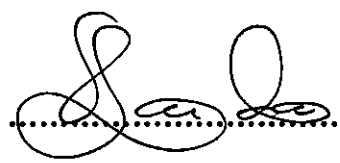

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ABSTRACT

The experiment was conducted at the On-Farm Research Division (OFRD), Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI) Daulatpur, Khulna during the period from December, 2011 to March, 2012 to study the effects of spacing and fertilizer on the growth and yield of onion. Three spacings viz. 10 × 10 cm, 15 ×10 cm and 15 × 15 cm with three fertilizer combinations viz. soil test based fertilizer dose (STB); integrated plant nutrient system (IPNS) based fertilizer dose and farmers' practice were studied on the growth and yield of onion. The two factor experiment was laid out in a randomized complete block design (RCBD) with three replications. The size of unit plot was 1.5 × 1.2 m. Thirty five day old seedlings of BARI Piaz 1 were transplanted on 26 th December, 2011. The results demonstrated that plant spacing had significant effects on growth, yield components and yield of onion. The widest spacing (15 × 15 cm) produced the highest individual bulb weight (23.41 g) and bulb diameter (3.91 cm) however the spacing 15 × 10 cm produced the highest yield (14.11 t/ha). The lowest yield (10 t/ha) was obtained from the widest spacing of 15 × 15 cm. Different fertilizers exhibited significant variation in respect of individual bulb weight, bulb diameter and yield. The maximum bulb weight (20.65 g) and yield (12.56 t/ha) were recorded in IPNS based fertilizer dose while farmers' practice produced the lowest yield (12.18 t/ha) which is statistically similar to that of IPNS based fertilizer dose. The combined effect of fertilizer and plant spacing had significant effect on growth and yield of onion. The highest yield (15.17 t/ha) was obtained from the spacing of 15 × 10 cm coupled with IPNS based fertilizer dose and the lowest yield (9.70 t/ha) was found in 15 × 15 cm spacing with farmers' practice.

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The Author

Dedicated

To

My Beloved Parents

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CHAPTER I

INTRODUCTION

Onion (*Allium cepa*) is an important bulb crop, belonging to the family Alliaceae. It is one of the most important and popular spice crops in Bangladesh as well as in the world. The main edible portion of onion plant is the bulb, which is a modified organ consisting of thickened fleshy scale leaves and the stem-plate. The crop was originated somewhere between western China and deserts lying east of the Caspian Sea (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, 2003). Onion is extensively used as condiment in the preparation of curry, chutney and pickle. It is an indispensable part of the Bangladeshi diet and is commonly used both by rich and poor but domestic production does not achieve even 15% of the annual requirement (Hossain and Islam, 1994). Onion ranks first among spices in respect of production and area in Bangladesh (BBS, 2010). The total area under onion cultivation is 290501 acres and its production is about 872081 metric tons (BBS, 2010). The yield of onion is very low (3.94 t/ha) in our country compared to the world average yield (17.00 t/ha), and it remained fairly static for the last five years (FAO, 2000). This production of onion can not fulfil our national demand. As a result, a huge amount of onion needs to import to meet our demand with the expense of our foreign currency. In the year of 2010, the authorized import was about 73587 ton costing 18589651 US dollar (BBS, 2010).

Onion production is greatly influenced by agronomic practices (Mondal *et al.* 1986). Manuring of soil is very important and proper manuring can play a vital role in increasing its yield. Use of inorganic fertilizer in crop production may cause health hazards, pollution of air, water and soil. The continuous use of chemical fertilizer badly affects the texture and structure of soil, decreases the soil organic matter, hamper soil microbial activity etc. On the other hand, uses of organic manure improves texture, structure, humus aeration, water holding capacity and microbial activity of soil and also keeps the environment free from pollution. A good soil should have an organic matter content of more than 3%. But in Bangladesh, soils of most regions contain the organic matter of less than 1%. It is believed that the decline productivity of Bangladesh soils is the result of depletion of organic matter caused by high cropping intensity (SRDI, 2005).

Animal manure supplies all major nutrients (N, P, K, Ca, Mg, S) necessary for plant growth, as well as micronutrients (trace elements), hence it acts as a mixed fertilizer. The chemical composition of fresh manures varies according to the type of feed and location. In general, the percentage of N, P_2O_5, K_2O, Ca, Mg, organic matter, and moisture in cow dung are: 0.5, 0.5, 0.3, 0.1, 16.7 and 81.3%, and that of poultry manure are: 0.9, 0.5, 0.8, 0.4, 0.2, 30.7 and 64.8%, respectively (Anonymous, 2007). In addition, a small fraction of the added organic material is transformed into humus or stable organic matter. Humus contributes to soil fertility by retaining plant nutrients through adsorption. It also acts as binding material in the soil, thus improving soil structure. It is responsible for making clay less susceptible to compaction caused by heavy traffic and silt less susceptible to erosion, and it increases water holding capacity and cation exchange capacity of soil (Brandjes *et al.*, 1996). Composted organic matter improves

soil physical characteristics, lowers C: N ratio, thus reducing competition for nutrients between plants and microorganisms, and the high temperature produced during composting process reduces the viability of soil borne pests and weed seeds (L'Hermite *et al.*, 1993). The use of proper agronomic practice has an undoubted contribution in increasing crop yield. The optimum level of any agronomic practice like plant spacing, plant population, planting date, harvesting time can bring desired results. The optimum use of spacing or plant population has dual advantages. It also avoids strong competition between plants for growth factor such as water, nutrient and light. Conversely, optimum plant population enables efficient use of available crop land without wastage (Zubelidia and Gases, 1977). Successful bulb production in onion depends on the plant spacing. Spacing influences the plant growth, size of bulbs, yields as well as the quality of the onion bulb (Badruddin and Haque, 1977). Planting at proper spacing increases the quality and size of onion bulb. Many workers reported that wider spacing caused higher yield per plant, although the closer spacing gave higher yield per unit area due to increased plant density up to a certain limit (Decampose *et al.* 1968). But very little work has so far been done in respect of spacing and organic-inorganic fertilizer combination under the agro-climatic condition of Khulna. Therefore, the present investigation has been carried out with the following objectives:

(i). to select the suitable spacing for onion production.

(ii). to find out the appropriate fertilizer for onion production.

CHAPTER II

REVIEW OF LITREATURE

Onion is one of the most important bulb crops. The production of onion bulb is influenced by many factors such as plant spacing and fertilization. Fertilizers play an important role on growth and yield of onion. To ensure better yield, the optimum combination of NPKS and plant spacing were to be assessed. A number of research works on plant spacing and NPKS application in onion have been conducted in different parts of the world, but information under Bangladesh conditions are limited. The present study has been undertaken to investigate the effect of plant spacing and fertilizer management system on the growth and yield of onion. Research findings related to the present study have been reviewed here.

2.1 Influence of plant spacing on the growth and yield of onion

Coelo *et. al.* (1996) conducted an experiment under three irrigation regimes and five spacings as 8 or 10 cm between plants and rows 10-30 cm apart. They found the highest yield of commercial bulbs at 20 × 8 cm spacing. This spacing gave the highest proportion of larger bulbs and the highest average bulb weight.

Stoffela (1996) worked with two onion cultivars- Sweet Spanish and Granex 33. He planted the cultivars in 2, 3 or 4 rows per bed at 7.6, 15.2 or 22.9 cm in row spacing resulting in populations ranging from 41000 to 246000 plants/ha. He found no interaction between number of rows per bed and in row spacing for onion yield and bulb size traits. It was also observed that marketable onion bulb linearly increased and average bulb size

decreased with the increasing number of rows per bed or row spacing decreased. Percentage of small, medium and large bulbs were unaffected by the number of rows per bed, but percentage of small and medium bulbs increased and percentage of large bulbs decreased as spacing decreased.

Glamarini *et al* (1995) carried out an experiment with four dates of planting and planting density. He reported that increasing number of plant density increased bulb yield. The yield of 29921 kg/ha was obtained from 156000 plants/ha. And 62864 kg/ha was obtained from 830000 plants/ha. It was also found that the increasing number of plant density decreased the bulb size.

Singh (1995) conducted two trials at Ranchi with plant spacing, nitrogen rate and phosphorus rate to study the response of onion. He found that the closest spacing gave higher number of marketable bulbs and yields. He also reported that the widest spacing gave the greater sizes of bulb.

Mehla *et al.* (1993) found in an experiment with onion row spacing and nitrogen levels. In their two years trial from 1991 to 1992, it was found that the increase of spacing, bulb size and weight increased, but the total yield decreased. They also reported that there was a significant interaction between spacing and nitrogen rate. The highest yield was obtained with 10 cm row spacing and 120 kg N/ha.

Rajas *et al.* (1993) investigated into the trial using four rates of sulphur (0, 40, 60 and 80 kg/ha), three plant spacings (10 × 15 cm, 15 × 15 cm and 20 × 15 cm) and irrigation at intervals of 5, 10 or 15 days. They stated that the highest yield (28.11 t/ha) was obtained with 80 kg S/ha, plant spacing of 10 × 15 cm and an irrigation interval of 5 days.

Rizk *et al.* (1991) worked with plant spacing on the growth, yield, yield components and bulb quality on onion as well as on the growth of associated weeds. They reported that the increasing row spacing had no significant effect on root measurement, number of leaves, bulb length and the yield. The increased plant spacing caused significant increases in the fresh weight and dry weight of bulbs. Marketable, non-marketable and total bulb yields were adversely affected by increased row spacing.

Khushk *et al.* (1990) studied with three inter (20, 30 and 40 cm) and three intra (10, 15 and 20 cm) row spacing to observe bulb yield and yield components. They reported that wider inter and intra-row spacing resulted in significant increases in number of leaves/plant, plant height and single bulb weight. The vertical diameter of bulb was significantly increased by wider intra spacing. They also obtained the highest bulb yield at an intra-row spacing of 20 × 10 cm.

Mondal and Brewster (1989) investigated the effect of shading and plant density on radiation interception, bulb development and yield of onion. They found that the high plant density gave higher yield, while shading caused an appreciable reduction in bulb yield.

Vishnu and Prabhakar (1989) conducted an experiment with onion cultivar Nasik and Red spaced at 15 × 10 cm, 15 × 15 cm and 15 × 25 cm applying nitrogen at 0, 75 or 150 kg/ha and P_2O_5 at 0 or 60 kg/ha in a 3 years trial. They found the highest yield with the closest spacing and the highest NP rates, but the benefit cost ratio was optimal at the closest spacing and N at 75 kg/ha. Lopes (1987) worked with some short day onion varieties and stated that the closer plant spacing gave the best yield of bulb.

Mondal *et al.* (1986) conducted an experiment with two dates of sowing (15 March and 21 April) and three planting density (25, 100 and 400 plants/m^2) for observing bulb yield in onion. They reported significant responses to density and sowing date with higher yield in closer spacing. Villagran and Escaff (1982) conducted an experiment with 5 levels of nitrogen from 0 to 120 kg/ha and 5 levels of plant density from 266666 to 800000 plants/ha. The highest marketable bulb was obtained with 571428 plants/ha. They also observed no interaction between plant density and nitrogen rate.

Hassan (1978) stated that in onion, the increased number of plants per unit area increased the total yield, but decreased average bulb weight, percentage of large bulb, splitting of bulbs and bolting. Badruddin and Haque (1977) carried out an experiment on the effects of time of planting and spacing with cv. White Globe. They found that wider spacing (20.32 X 30.48 cm) produced the highest yield, but plants were shorter and the size and weight of bulbs were less than wider spacing.

Bashar (1976) conducted an experiment at BAU with five spacings viz. 6, 10, 12, 15 and 18 inches in rows placed 2 feet apart. The height plant height was obtained from 6 inch spacing with 2 feet apart rows in potato. Rashid and Rashid (1976) conducted an experiment with onion in Bangladesh. They stated that the yield increased with the closer spacing due to larger number of plants per unit area. Closer spacing also caused the plants to produce fewer and shorter leaves and smaller bulbs.

Vik (1972) observed a density of 60 plants/m^2 to be the most favorable for early harvest and best keeping quality for direct sown onion. They observed that with increasing plant density, maturity was advanced, bulb size was reduced and storage quality was improved and with decreasing plant density, bulb size was increased but maturity was delayed.

Singh (1972) conducted an experiment to investigate the effect of nitrogen application and spacing on the growth and yield of onion using three levels of nitrogen (70, 90 and 110 kg/ha) and three levels of spacing (10 × 30 cm, 20 × 30 cm and 30 × 30 cm) and found that the closest spacing gave the bigger and heavier bulbs. The interaction effect between nitrogen and spacing was significant for bulb size and yield. Application of N at 70 kg/ha and 30 × 30 cm spacing gave the biggest bulbs and N at 90 kg/ha and spacing of 30 × 10 cm gave the highest yield/ha.

Verma *et al.* (1972) observed that the closer spacing resulted in higher yields than that of wider spacing. Their recombination was 9 × 15 cm. Khandelwa and Maiti (1971) found that the widest spacing increased the yield of onion per plant, but the closest spacing increased the yield of onion per hectare. Nichols and Heydecker 9 (1964) carried out an experiment with onion and they observed that onions planted at 10.16 × 15.24 cm gave the highest yield and there was significant increase in yield when the rows were 15.24 cm apart as compared to 30.48 cm, 45.72 cm and 60.96 cm.

2.2 Influence of fertilizer on the growth and yield of onion

Rizk (1997) worked on an experiment to investigate the effects of plant density (2 or 3 lines/ridge) and NPK fertilizers (4 rates and 2 method of application) on the productivity of onions. Lower planting densities resulted in higher number of leaves/plant, higher fresh and dry weight; higher leaf areas, higher average bulb weights and higher uptake of N. Total bulb yield and yield of marketable bulbs were the highest with dense planting. Increasing the NPK rate increased all vegetative growth parameters measured and increased the yield of bulbs.

Dixit (1997) carried out an experiment during the summer of 1994 in Lari, Himachal Pradesh, India. He worked with five rates of nitrogen (80, 120 and 160 kg/ha) and two rates of farmyard manure (10 and 20) and reported that increasing nitrogen application rates increased bulb up to 120 kg N/ha. Higher yields were also obtained with the higher rate of farmyard manure. Application of 120 kg N/ha with 20 t/ha farmyard manure increased yields by 42.79% as compared to the control.

Singh *et al.* (1996) reported that the effects of N (0, 60, 120 or 80 kg/ha) and S (0, 20, 40 or 80 kg/ha) on the growth of onion (cv. Pusa red) were investigated in Aga, lndia in 1991-93. The yield and plant N content significantly increased with increasing rate of N. Combined addition of NS significantly influenced yield. Amin *et al.* (1995) worked in sandy loam soil in Mymensing on onion cv. Taherpuri. They planted on 20 December and 20 January and gave 0, 25, 50 or 100 kg N/ha. Yields were the highest from the planting of 20 December supplied with 100 kg N/ha. Individual bulb weight was also greater in the treatment.

Katwale and Saraf (1994) stated that the largest bulb yield was obtained with the application of NPK at the rate of 125: 60: 100 kg/ha, respectively. They also reported that the rate gave the highest economic return. Vachhani and Patel (1993) worked with the effects of nitrogen (50, 100 or 150 kg N/ha), phosphorus (25, 50 or 75 kg P2O5/ha) and potash (50, 100 or 150 kg K_2O/ha) levels on the growth and yield of onion. They reported that plant height, number of leaves/plant; bulb weight and yield were highest with 150 kg N/ha, although bulb weight and yield with 100 kg N/ha were not significantly different. Increasing phosphorus application increased the number of leave per plant and weight, size and yield of bulbs. Application of K increased only the number of leaves per plant.

Nasiruddin *et al.* (1993) conducted an experiment on the effect of potassium and sulphur on growth and yield of onion in Mymensingh, Bangladesh. They reported that application of both potassium and sulphur either individually or combined increased the plant height, leaf production ability of the plant, bulb diameter, bulb weight as well as the bulb yield.

Sharma (1992) worked with planting materials, nitrogen levels (0, 50 of 100 kg N/ha) and potash (0, 40 or 80 kg K_2O/ha) to know the bulb yield of onion. He observed that significantly higher bulb yield was obtained with 50 kg N/ha as compared to no nitrogen in all the years, but increased bulb yield was achieved with the application of 100 kg N/ha only in 1988. Rahim *et al.* (1992) conducted an experiment on fertilizer dose and found that spacing of 25 cm x 25 cm, supplied with 0-160 kg K/ha and 0-100 kg N/ha, half before planting and half 36 days after planting resulted in the yield of 11.11 t/ha compared to 4.5 t/ha from control plots.

Pandey *et al.* (1991) studied with four levels of nitrogen (0, 50 and 150 kg/ha), three levels of phosphorus (0, 40 or 80 kg/ha) and two levels of potash (0 and 50 kg/ha) to determine the yield and quality of kharif onion. They found that the maximum yield and net return were achieved with NPK at 150: 40: 50 kg/ha. Pandey *et al.* (1990) conducted an experiment with various levels of N and reported that the highest yield of marketable bulbs (34.97 t/ha) were obtained by applying 100 kg N/ha.

Maier *et al.* (1990) stated that in onion crop fresh weight increase was correlated with the increase in N level and the largest bulbs were 25-30 mm in diameter. Nitrogen rates in the range 299-358 kg/ha gave 95% of maximum yield. Dry matter of bulbs was not affected by N. Bulb size increased as the rate of applied N increased. Ahmed *et al.* (1988) studied different levels of nitrogen (0, 60 and 120 Kg/ha) and sulphur (0, 12, 24 and 36 kg/ha) on a local cultivar of onion, Faridpuri Bhati. Both nitrogen and sulphur significantly increased the yield. However, a combined application of nitrogen and sulphur produced higher yield than nitrogen or sulphur alone. Nitrogen at 60 kg/ha together with sulphur at 36 kg/ha produced maximum yield (10.44 t/ha).

Hedge (1988) carried out an experiment with cv. Pusa Red and noticed that application of nitrogen fertilizer increased bulb yield but not quality. He also showed that uptake of N, P, K, Ca and Mg nutrients generally increased due to higher dry matter production. Singh *et al.* (1988) conducted an experiment and found that a combination of 120 kg N and 50 kg K_20 gave the tallest plants, the greatest number of leaves per plant, higher bulb weight per plant and diameter and higher bulb yield.

Palled *et al.* (1988) conducted a field experiment with N fertilizer. They showed that application of 100 kg N/ha gave 12.2 and 26.4% higher yields than 75 and 50 kg N/ha respectively. The consumptive use of water increased with increasing irrigation frequency.

Laughlin (1988) worked on onion with different methods of fertilizer application. Factorial combination of 0, 50, 100 and 200 kg/ha of both N and P were banded at drilling. The N fertilizer had no effect on either yield or quality, but P increased 26% yield by top dressing with 50 kg N/ha. He reported that K showed no response without top dressing of N. Soto (1988) carried out an experiment with critical levels for P, K and S response to N. The rates were 100 kg/ha each of N, P_2O_5 and K_2O and 50 kg S/ha. Nitrogen was applied at 0, 50, 100 and 150 kg/ha. He mentioned that 50 kg N/ha gave the best yield response.

Singh (1987) in his trial with onion cv. Pusha Red at different levels and combination of NPK fertilizers observed a significant response from N but not from K. The highest yield (26.04 t/ha) was obtained with N and P_2O_5 at 112.5 and 196.9 kg/ha respectively. Beresniewiez and Nowosiecski (1986) reported that application of 200 kg N, 200 kg P_2O_5, 200 kg K_2O, 20 kg Mg, 5 kg Mn, 5 kg Zn, 10 kg Cu and 15 kg Mo/ha gave the highest yield. Yield was further increased when organic fertilizer (lignite or peat) at 100 t/ha and Ca at 2 t/ha were applied at the same time. Madan and Sandhu (1985) noticed that good plant growth and maximum bulb yield and dry matter yields were obtained with N: P_20_5: K_2O at 120: 60: 60 kg/ha.

Smittle (1984) worked on N and S nutrition on the yield, quality and storage life of Granex onion and reported that sulphur application as gypsum 1600 lb gypsum/acre) consistently increased onion pungency and usually resulting in a lower preference for the bulbs. Rashid (1983) recommended 10 tons of cow dung, 175 kg of Urea 125 kg of TSP and 150 kg of MoP per hectare for successful onion cultivation in Bangladesh.

Gupta and Gaffar (1980) conducted an experiment to study the effect of different row spacing under different combinations of nitrogen, phosphorus and potassium on the growth and yield of onion. Application of NPK exerted a significant effect on the yield and yield contributing characters of onion. Economic yield was obtained from NPK applying at the rate of 46: 36:36 kg/ha. Bhuyan and Haque (1979) in Bangladesh observed the rate of nitrogen and potash at 63.37 kg and 67.31 kg per hectare respectively applied in different split combinations. The result showed that the split-application of nitrogen and potash gave significantly higher yield than the entire dose at planting. Splitted doses with higher amount of nitrogen and potash at initial stage of growth seemed to be more appropriate for the higher yield of onion.

Paterson (1979) found that the yield was increased by 22.48 percent with the application of sulphur at 17 kg/ha. Katyal (1977) suggested 15 to 20 tons FYM and 100 kg ammonium sulphate, 175 kg super phosphate and 130 kg of potassium sulphate per hectare before transplanting in early stage of growth of onion crop. Islam and Haque (1977) in Bangladesh studied the effect of NPK on an indigenous cultivar of onion, and observed that the combined dose of nitrogen at 60 kg/ha, phosphorus at 35 kg/ha and potash at 35 kg/ha produced the highest yield.

Rahman *et al.* (1976) studied the effect of NPK on the local onion cv. Faridpuri Bhatti in Bangladesh. They found that a combined dose of nitrogen at 56 kg/ha and potash at 67 kg/ha produced the best results in order to get the highest yield. Higher level of nitrogen application (112 kg/ha) resulted in decreased yield but increased levels of potassium (135 kg/ha) increased the size of bulbs

Satter and Haque (1975) observed that an increased level of nitrogen increased the weight of bulb; while potassium in an increased level decreased the bulb weight. In their study, nitrogen at 67.21 kg and potassium at 22.48 kg/ha were found to give a high yield of onion. Rahman and Faruque (1975) studied the effect of NPK on onion cv. White Creole and found that an application of N: P: K at the rate of 90: 45:45 kg/ha resulted in the highest yield.

Bari (1974) stated that a dose of 66: 88: 88 kg N, P_2O_5 and K_2O per hectare gave the highest yield of onion. Lazo *et al.* (1969) in their trial on the use of NPK fertilizers in onion at the rate of 50, 100, 150 kg per hectare observed that nitrogen used alone or in combination with phosphorus and potash gave the highest yield. Wayes (1967) had a NPK trial on the Kharif and Rabi onion. Kharif onion was found to respond significantly to application of 18 kg nitrogen, 28 kg potassium per acre, showing the increase in yield by 30, 10, and 69 percent respectively. Misra and Prasad (1966) conducted a field trial with fertilizer on pungency and yield of onion. They showed that a suitable dressing of sulphur fertilizer improved growth, yield, and pungency and also increased the availability of trace elements.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental location

The experiment was conducted to study the effects of fertilizer and plant spacing on the growth and yield of onion at the On-Farm Research Division (OFRD), Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI) Daulatpur, Khulna during the period from December, 2011 to March, 2012.

3.2 Physical and chemical properties of soil

The experimental area was medium high land and the soil was sandy to clay loam. The nutrient status of the soil of the experimental plot was analyzed at SRDI, Daulutpur, Khulna prior to cultivation. Chemical characteristics of the soil of this experiment field is shown below.

Constituents	N	P	K	S	Zn	B	pH	Salinity	OM
Amount	0.27%	46.65 ppm	0.35 me/100g	81.64 ppm	5.01 ppm	0.74 ppm	7.5	7.22 dS/m	4.81%

3.3 Climate

The experimental area was under the sub-tropical climate zone, which is characterized by heavy rainfall, high humidity, high temperature, and relatively long day during the kharif season and hardly rainfall, low humidity, low temperature and short day period during the rabi season. Details of the meteorological data during the experimental period are listed below.

Monthly mean temperature, total rainfall, relative humidity and sunshine during crop period at the experimental site

Month	Temperature (°C)	Rainfall (mm)	Humidity (%)	Sunshine (hrs)
December,2011	19.8	20 mm	83.58	5.18
January, 2012	19.35	12 mm	80.28	6.03
February,2012	22.37	10 mm	73.25	8.41
March, 2012	27.9	68.2 mm	76.23	8.36

Source: Bangladesh Agricultural Research Institute, OFRD, Daulatpur, Khulna.

3.4 Variety

BARI Piaz 1, a high yielding variety was considered for this study as a test material. Thirty five days old seedlings were collected from Spices Research Station, BARI, Magura. The variety produces plant of 50-60 cm tall with 10-12 leaves per plant. The average weight of individual bulb is 20-30g and the diameter is 3-4 cm. The bulbs are rhombic and highly pungent with pinkish red skin and most of the bulbs are single type, mature at 130-140 days, bulbs have long shelf life and the yield is about 12-16 t/ha.

3.5 Land preparation

The land was first ploughed in the 12 th December, 2011 with power tiller. After that the land was exposed to sunlight for five days. The ploughing was followed by laddering to obtain good tilth and this process was repeated until getting a loose soil. During land preparation weeds and stubbles were collected and removed from the

field and the clods were broken. Seedlings were transplanted on 26 th December, 2011.

3.6 Treatment and layout of the experiment

The experiment comprised three different plant spacings and three different fertilizers.

A: Spacing

i. Close: 10 × 10 cm (S_1)

ii. Medium: 15 × 10 cm (S_2)

iii. Wide: 15 × 15 cm (S_3)

B: Fertilizer

F_1- Soil test based fertilizer dose (N 30 kg/ha; P 18 kg/ha; K 30 kg/ha and S 5 kg/ha).

F_2- IPNS ((N 7.5 P 0.5 Kg/ha) based fertilizer dose + cow dung 5ton/ha.

F_3- Farmers' practice (N 115 kg/ha; P 82 kg/ha and K 125 kg/ha).

3.7 Experimental design

The two factor experiment was laid out in a randomized completely block design (RCBD). The whole field was first divided into 3 blocks each containing 9 plots. In total there were 27 unit plots. The treatment combinations were assigned randomly in each unit plot so as to keep one treatment only in each block. The size of each unit plot was 1.5 × 1.2 m. The space left between plots and replication was 1 m.

3.8 Fertilizer application

During land preparation all the fertilizer except urea were applied according to the recommended experimental design as a basal dose. The selected 3 fertilizer combinations were applied in the treatment of unit plots. Top dressing with urea was applied in two equal splits, at 20 and 50 days after transplanting.

3.9 Intercultural operation

Various kinds of intercultural operations were accomplished for better growth and development of the plants.

Gap filling: Gap filling was done using healthy plants as per requirement.

Weeding and mulching: Weeding and mulching were accomplished as and when required to keep the crop free from weeds and to conserve the soil moisture.

Irrigation: Irrigation was given by both watering can and hose pipe as and when needed. Seedlings were first irrigated just after transplanting and then they were irrigated whenever required to conserve the optimum moisture level to the soil.

Plant protection: To avoid pest and fungal infection seedlings were sprayed with Antracol @ 0.2% after 1 month of sowing and sprayed with Rovral @ 0.2% and Tilt @ 0.2% after 45 days of transplanting.

Harvesting: The crop was harvested on 23 rd March, 2012 when more than 75% of the tops had fallen over. The tops were removed by cutting off the pseudo-stem keeping 2.5 cm with the bulb.

3.10 Data collection

Data of the following parameters were recorded from the sample plants. Ten plants were selected randomly form each plot in such a way so that the border effect could be avoided.

3.10.1 Plant population per square meter

The total number of plants in a square meter area were counted and recorded.

3.10.2 Plant height (cm)

The height of the selected plant was measured after harvesting the crop with a centimeter scale. The height was measured in centimeter from the neck of the bulb to the tip of the longest leaf.

3.10.3 Number of leaves per plant

The number of leaves/plant was counted from randomly selected 10 plants taken from each plot after harvesting the crops.

3.10.4 Bulb length (cm)

The length of bulb was measured with a centimeter scale from pseudo-stem to the bottom of the bulb taken from 10 randomly selected plants from each plot.

3.10.5 Bulb diameter (cm)

The diameter of bulb at harvest was measured at the middle portion of bulb taken from 10 randomly selected plants with slide calipers.

3.10.6 Individual bulb weight (g)

Ten plants were selected from each unit plot. The top was removed by cutting the pseudo-stem keeping only the 2.5 cm from the bulb (A- AS-Saqui, 1994). Ten bulbs were weighed by a simple balance and the average was taken.

3.10.7 Yield of onion (t/ha)

The yield of bulb per unit plot was converted into tons per hectare.

3.11 Statistical analysis:

The collected data on various parameters were statistically analyzed. The mean for all the treatments were calculated and analysis of variance for the all the character were performed by F-test. The significance of the difference between the pairs of means was evaluated by Duncan's new Multiple Range Test (Gomez and Gomez, 1984).

CHAPTE IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the experiment. The growth and yield components such as plants per square meter, plant height, leaf number, bulb length, bulb diameter, bulb weight and finally yield of the bulbs influenced by spacing and fertilizer doses are presented in Table 1-3.

Table 1. Yield and yield attributes of onion influenced by spacing

Spacing	No. of plants /m^2	Plant height. (cm)	No. of leaves/plant	Bulb length (cm)	Bulb diameter (cm)	Individual bulb wt. (g)	Yield (t/ha)
S_1	98.00 a	57.64 a	9.46	3.27	2.61 c	14.13 b	12.57 a
S_2	60.50 b	52.24ab	10.45	3.05	3.47 b	23.07 a	14.11 a
S_3	43.33 c	49.34 b	10.18	3.02	3.91 a	23.41 a	10.00 b
CV (%)	4.03	13.26	13.30	11.12	9.66	21.02	15.98
Level of significance	*	*	NS	NS	*	*	*

Means in a column followed by the same letter(s) or without letter(s) are not significantly different at the 5% level by DMRT.

*Significant at 5% level of probability, NS- Non significant.

Note:

S_1- 10 X 10 cm

S_2- 15 X 10 cm

S_3-15 X 15 cm

Plot size -1.5 X 1.2 m

Table 2. Yield and yield attributes of onion influenced by fertilizer

Fertilizer dose	No. of Plants /m^2	Plant height. (cm)	No. of leaves/plant	Bulb length (cm)	Bulb diameter (cm)	Individual bulb wt. (g)	Yield (t/ha)
F_1	67.27	56.04	10.31	3.05	3.18 b	19.98 b	11.94 b
F_2	67.83	50.84	9.31	3.28	3.31 a	20.65 a	12.56 a
F_3	67.05	52.34	10.47	3.01	3.5 a	19.99 a	12.18 a
CV (%)	4.03	13.26	13.30	11.12	9.66	21.02	15.98
Level of significance	NS	NS	NS	NS	*	*	*

Means in a column followed by the same letter(s) or without letter(s) are not significantly different at the 5% level by DMRT.

*Significant at 5% level of probability, NS- Non significant.

Note:

F_1- Soil test based fertilizer dose ($N_{30} P_{18} K_{30} S_6$ kg/ha)

F_2- IPNS ($N_{7.5} P_{0.5}$ kg/ha) based fertilizer dose + cow dung 5 ton/ha.

F_3- Farmers' practice ($N_{115} P_{82} K_{125}$ kg/ha).

Table 3. Combined effect of spacing and fertilizer on the yield and yield attributes of onion

Treatments	No. of Plants /m^2	Plant height. (cm)	No. of leaves/plant	Bulb length (cm)	Bulb diameter (cm)	Individual bulb wt. (g)	Yield (t/ha)
S_1F_1	97.38 a	67.11 a	8.78 b	3.25 ab	2.50 c	12.47 c	12.33 abc
S_1F_2	98.33 a	52.33 b	8.68 b	3.56 a	2.65 c	17.30 bc	13.72 ab
S_1F_3	97.61 a	53.49 b	10.92 ab	3.00 ab	2.68 c	12.62 c	11.67 bc
S_2F_1	60.50 b	52.18 b	11.58 a	3.00 ab	3.43 b	23.27 ab	14.47 ab
S_2F_2	61.11 b	51.92 b	9.30 ab	3.25 ab	3.68 ab	24.74 ab	15.17 a
S_2F_3	61.27 b	52.62 b	10.47 ab	3.05 ab	3.30 b	22.23 ab	12.70 abc
S_3F_1	43.88 c	48.82 b	10.55 ab	2.91 b	4.00 a	22.72 ab	10.13 c
S_3F_2	44.07 c	48.28 b	9.96 ab	2.91 b	4.13 a	25.11 a	10.17 c
S_3F_3	42.22 c	50.92 b	10.03 ab	2.95 b	3.60 ab	21.38 ab	9.70 c
CV (%)	4.03	13.26	13.30	11.12	9.66	21.02	15.98
Level of Significance	*	*	*	*	*	*	*

Means in a column followed by the same letter(s) or without letter(s) are not significantly different at the 5% level by DMRT.

*Significant at 5% level of probability, NS- Non significant.

Note:

S_1- 10 X 10 cm

S_2- 15 X 10 cm

S_3-15 X 15 cm

F_1- Soil test based fertilizer dose ($N_{30} P_{18} K_{30} S_6$ kg/ha)

F_2- IPNS ($N_{7.5} P_{0.5}$ kg/ha) based fertilizer dose + cow dung 5 ton/ha.

F_3- Farmers' practice ($N_{115} P_{82} K_{125}$ kg/ha).

4.1 Number of plants per square meter

The number of plants per square meter were significantly influenced by spacing. The highest number of plants (98) found in S_1 (10 × 10 cm) and lowest (43.33) were recorded from the S_3 (15 × 15 cm) (Table 1). Singh (1995) reported that the closest spacing gave higher number of bulbs whether the widest spacing gave lower number of bulbs.

The number of plants per square meter has no significant effect when treated with fertilizer (Table 2).

The combined effect of spacing and fertilizer dose on number of plants was found statistically significant (Table 3). The highest number of plants (98.33) recorded in S_1 (10 × 10 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 t/ha) and the lowest (42.22) was recorded from S_3 (15 × 15 cm) with F_3 ($N_{115} P_{82} K_{125}$).

4.2 Plant height

The plant height was significantly influenced by plant spacing. The highest plant height (57.64 cm) was obtained from the closer spacing S_1 (10 × 10 cm) which (52.24 cm) was statistically identical with S_2 (15 × 10 cm) and the lowest plant height (49.34) was found in S_3 (15 × 15 cm) (Table 1). The Increased plant height at the closest spacing was probably due to competition for light, nutrient and space. Bashar (1976) found similar result as influenced by plant spacing.

The plant height had no significant effect on fertilizer dose (Table 2). It may be due to the inherent characteristics of BARI Piaz 1.

The Combined effect of spacing and fertilizer dose was found statistically significant in respect of plant height (Table 3). The highest plant (67 cm) was recorded from closet spacing S_1 (10 × 10 cm) with F_1 ($N_{30} P_{18} K_{30} S_6$ kg/ha) and the lowest height (48.28 cm) was recorded in widest spacing S_3 (15 × 15 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 t/ha). This result agrees with finding of Das and Dhyni (1956) who found highest plant height from closer spacing with 89 kg N/ha.

4.3 Number of leaves per plant

The number of leaves per plant was statistically non-significant on both spacing and fertilizer dose. This may be due to genetic characteristics of the onion variety that dominate over the both fertilizer and spacing.

The number of leaves per plant was significantly influenced by the combined effect of spacing and fertilizer dose. The highest number of leaves per plant (11.58) was found in S_2 (15×10 cm) with F_1 (N_{30} P_{18} K_{30} S_6 kg/ha) that was statistically similar with all other treatments except S_1 (10×10 cm) with F_1 (N_{30} P_{18} K_{30} S_6 kg/ha) and S_1 (10×10 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 t/ha) and it also produced lowest number of leaves (8.68) (Table 3).

4.4 Bulb length

The bulb length of the plant was statistically non-significant in both spacing and fertilizer dose. The highest bulb length (3.27 cm) found in S_1 (10 × 10 cm) and the lowest (3.02 cm) in S_3 (15 × 15 cm) in case of spacing (Table 1) and for fertilizer dose, the highest bulb length (3.28) in F_2 (IPNS based fertilizer dose + cow dung 5 t/ha) and the lowest (3.01 cm) was recorded in F_3 ($N_{115} P_{82} K_{125}$ kg/ha) (Table 2).

Singh (1972) also found that wider spacing of 30 × 30 cm with 70 kg N/ha gave larger bulbs.

4.6 Individual bulb weight

Bulb weight was significantly influenced by plant spacing. The highest bulb weight (23.41 g) was recorded in S_3 (15 × 15 cm) and followed by 23.07 g that was found in S_2 (15 × 10 cm) and the lowest bulb weight (14.13 g) was observed in S_1 (10 × 10 cm) (Table 1). As wider spacing accommodated less number of plants per unit area, the plant obtained sufficient nutrients, moisture and light, which helped the production of bulbs of higher weight. Mehla *et al.* (1993), Coelo *et al.* (1996) and Singh (1972) demonstrated that the fresh weight of bulb was higher at wider spacing.

Different combination of fertilizers significantly influenced the individual weight of bulbs. The maximum bulb weight (20.65 g) was obtained from F_2 (IPNS based fertilizer dose + cow dung 5 t/ha) and it was statistically similar with F_3 ($N_{115} P_{82} K_{125}$ kg/ha) and the lowest (19.98 g) found in F_1 ($N_{30} P_{18} K_{30} S_5$ kg/ha) (Table 2).

The weight of bulb significantly influenced by combined effect of spacing and fertilizer dose. The maximum bulb weight (25.11 g) was found in S_3 (15 × 15 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 t/ha.) and the lowest (12.47 g) observed in S_1 (10 × 10 cm) with F_1 ($N_{30} P_{18} K_{30} S_5$ kg/ha) (Table 3). The result is agreed with Singh (1972), who found the highest bulb weight from a wider plant spacing 10 × 30 cm.

4.7 Bulb yield

The bulb yield was significantly influenced by plant spacing. The maximum yield (14.11 t/ha) was obtained from the closer spacing S_2 (15 × 10 cm). The second highest yield (12.57 t/ha) was recorded from S_1 (10 × 10 cm) and it was statistically identical with S_2 (15 × 10 cm) and the lowest yield (10 t/ha) was found when seedling were transplanted with spacing of S_3 (15 × 15 cm) (Table 1). In the closest spacing plants had to compare with each other for air, space and nutrient, as a result their individual bulb weight decreased so that ultimately affected the yield, on the other hand in widest spacing plants got enough air, space and nutrient and their individual bulb weight was increased but their number of plants were less per unit area. This result is similar to Nicholas and Heydecker (1964) who found that spacing of 15.24 × 10.5 cm gave the higher yield.

The yield of bulbs was significantly influenced by fertilizer dose. The maximum yield (12.56 t/ha) was recorded in F_2 (IPNS based fertilizer dose + cow dung 5 t/ha) and the lowest yield (11.94 t/ha) found in F_1 ($N_{30} P_{18} K_{30} S_6$ kg/ha) (Table 2). IPNS is designed nutrient system for plant; it provided the optimum nutrient to the plants, so yield is higher compare to other fertilizer doses. Dixit (1997) found that favorable influence of organics, inorganics and bio-fertilizers on chemical, physical and biological properties of soil under IPNS would have resulted maximum bulb yields of onion.

Bulb yield was significantly influenced by the combined effect. The maximum bulb weight (15.17 t/ha) found in S_2 (15 × 10 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 t/ha) and the lowest yield (9.70 t/ha) recorded in S_3 (15 × 15 cm) with F_3 ($N_{115} P_{82} K_{125}$ kg/ha) (Table 3).

CHAPTER V

SUMMARY AND CONCLUSION

An experiment was conducted in order to study the effects of spacing and fertilizer on the growth and yield of onion var. BARI Piaz 1 at the On-Farm Research Division (OFRD), Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI) Daulatpur, Khulna during the period of December, 2011 to March, 2012.

The experiment was laid out in a randomized completely block design (RCBD) with three replications. Plot size was 1.5 × 1.2 m. Data were recorded on plant population per square meter, plant height, leaves per plant, bulb length, bulb diameter, individual bulb weight and yield.

Plant population per plot was significantly influenced by spacing treatment the highest plant population (98) were recorded in S_1 (10 × 10 cm) and the lowest (43.33) found in S_3 (15×15 cm) where fertilizer had no significant effect on plant population per square meter. The combined effect of spacing and fertilizer dose on the number of plants was found statistically significant. The highest number of plants (98.33) recorded in S_1 (10 × 10 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 ton/ha) and the lowest (42.22) recorded from S_3 (15 × 15 cm) with F_3 ($N_{115} P_{82} K_{125}$).

The highest plant height (57.64 cm) was obtained from the closer spacing of S_1 (10 × 10 cm) and the lowest plant height (49.34) was found in S_3 (15 × 15 cm) and it had no significant effect on fertilizer dose. The combined effect of spacing and fertilizer dose was found statistically significant in respect of plant height. The highest plant height (67.11 cm) was recorded from closest spacing S_1 (10 × 10 cm) with F_1 ($N_{30} P_{18} K_{30}$

S_6 kg/ha) and the lowest height (48.28 cm) was recorded in the widest spacing S_3 (15 × 15 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 ton/ha).

The number of leaves per plant was statistically non-significant in case of spacing and fertilizer. The number of leaves was significantly influenced by the interaction effect of spacing and fertilizer dose. The height number of leaves (11.58) was found in S_2 (15×10 cm) with F_1 ($N_{30}P_{18}K_{30}S_6$ kg/ha) and the lowest number of leaves (8.68) recorded in S_1 (10 × 10 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 ton/ha)

The bulb length of the plant was also statistically non-significant in spacing and fertilizer but it was significantly influenced by the combined effect of spacing and fertilizer dose. The maximum bulb length (3.56cm) was observed from S_1 (10 × 10 cm) with F_1 ($N_{30}P_{18}K_{30}S_6$ kg/ha) and lowest (2.91 cm) recorded in S_3 (15× 15 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 t/ha).

Bulb diameter was significantly influenced by both spacing and fertilizer dose, the maximum bulb diameter (3.91 cm) was found in S_3 (15 × 15 cm) and the lowest bulb diameter (2.61 cm) found in S_1 (10 × 10 cm). For fertilizer dose maximum bulb diameter (3.5 cm) from F_3 ($N_{115}P_{82}K_{125}$ kg/ha) and the minimum (3.18 cm) recorded in F_1 ($N_{30}P_{18}K_{30}S_6$ kg/ha). Bulb diameter was significantly influenced by the interaction effect of spacing and fertilizer dose. The maximum bulb diameter (4.13 cm) was obtained from S_3 (15 × 15 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 ton/ha) and the minimum bulb diameter (2.50 cm) recorded in S_1 (10 × 10 cm) with F_1 ($N_{30}P_{18}K_{30}S_6$ kg/ha).

In bulb weight, the highest bulb weight (23.41 g) recorded in S_3 (15× 15 cm) and followed by 23.07 g that was found from S_2 (15 × 15 cm) and the lowest bulb weight (14.13 g) observed in S_1 (10 × 10 cm) and it was significantly influenced by spacing.

Fertilizer dose significantly influenced the individual weight of bulbs. The maximum bulb weight (20.65 g) was obtained from F_2 (IPNS based fertilizer dose + cow dung 5 ton/ha) and the lowest (19.98 g) found in F_1 ($N_{30}P_{18}K_{30}S_6$ kg/ha) and it also statistically significant in combined effect. The maximum bulb weight (25.11 g) was found in S_3 (15 × 15 cm) with F_2 (IPNS based fertilizer dose + cow dung 5 ton/ha) and lowest (12.47 g) observed in S_1 (10 × 10 cm) with F_1 ($N_{30}P_{18}K_{30}S_6$ kg/ha).

The bulb yield was significantly influenced by plant spacing. The maximum yield (14.11 t/ha) was obtained from the closer spacing S_2 (15 × 10 cm) and lowest yield (12.57 t/ha) recorded in S_1 (10 × 10 cm) and it was also found significant in case of fertilizer dose, maximum yield (12.56 t/ha) was recorded in F_2 (IPNS based fertilizer dose + cow dung 5t/ha) and the lowest yield (11.94 t/ha) found in F_1 ($N_{30}P_{18}K_{30}S_6$ kg/ha). The maximum bulb weight (15.17 t/ha) found in S_2 (15 × 10 cm) with F_2 (IPNS + cow dung 5 t/ha) and lowest yield (9.70 t/ha) recorded in S_3 (15 × 15 cm) with F_3 ($N_{115}P_{82}K_{125}$) kg/ha due to the combined effect.

The above result suggested that the most effective combination for high yield of onion was the spacing of S_2 (15 × 10 cm) with fertilizer combination of F_2 (IPNS based fertilizer dose + cow dung 5 t/ha).

CHAPTER VI

REFERENCES

Ahmed, M. K, D. K. Aditya and M. A. Siddque. 1988. Effect of nitrogent and sulphur application on the growth and yield of onion. cv.Faridpru Bhatti. Bangladesh Hort., 16 (1): 36-41.

Amin, M. M. U, M. A. Rahim and M. A. Hashem. 1995. Influence of planting time and nitrogen on the growth and yield of onion. Bangladesh J. Sci. and Ind. Res., 30 (2-3): 275-279.

Anonymous. 2007. Manure an excellent Fertilizer. http://www.echochem.com/ t_manure _fert.html. Accessed 12/4/2007.

Badaruddin, M. and M. A. Haque. 1977. Effect of time of planting and spacing on the yield of onion (*Allium cepa* L.). Bangladesh Hort., 5 (2): 23-29.

Bari, M. A. 1974. Effect of NPK and irrigation on the yield of onion (*Allium cpea* L.). M. Sc. (Ag.) thesis, Department of Agronomy, BAU, Mymensingh.

Bashar, M. A. 1976. The effect of spacing on the growth and the yield of potato. M. Sc. (Ag.) thesis, Department of Horticulture, BAU, Mymensingh.

BBS, 2010. Yearbook of Agriculture Statistics of Bangladesh. Crop estimate, Chapter 3.

BBS, 2010.Yearbook of Agriculture Statistics of Bangladesh. Export and import of Agricultural products and inputs, Chapter 11.

Beresniewiez, A. and O. Nowosiecski. 1986. Effect of increasing rate of mineral fertilizer with simultaneous application of organic fertilizers and liming on vegetable yields and soil salinity. Biuletyn Warzaywniczy, 26 (2): 41-62.

Bhuyan, M. A. J. and M. A. Haque. 1979. Effect of split application of nitrogen and potash on the growth and yield of onion. Bangladesh Hort., 7(1/2): 36-37.

Branjes, P. J., J. de Wit, H. G. van der Meer and H. van Keulen. 1996. Environmental Impact of Animal Manure Management: International Agriculture Center, Wageningen, Netherlands. http://www. fao.org.

Coelo, E. F., V. A. B. Souza-de, M. A. F. Conceicao and V. A. B. De souza. 1996. Performance of onion crops under three irrigation regimes and five spacing. Pesquisa –Agropecuaria- Brasileira, 31 (8): 585-591.

Das, B. C. and K. C. Dhyani. 1956. Influence of different spacing and nitrogen fertilizer on growth and yield on onion. Phyton, 6: 47-56.

Decampose, H. R., L. D. S. Comangoo and E. Abramides. 1968. The effect of bulb spacing on onion seed production. Bragantia, 27: 79-82.

Dixit, S. P. 1997. Response of onion (*Allium Cepa* L.) to nitrogen and farm yard manure in dry temperate high hills of Himachal Pradesh. Indian J. Agril. Sci., 67 (5): 222-223.

FAO, 2003. Production year book. Food and Agriculture organization of United Nations, Rome, Italy, 57: 91-94.

FAO, 2000. Production year book. Food and Agriculture organization of United Nations.

Galmarini, C. R., P. G. Della Gaspera and P. G. Della-Gaspera. 1995. Effect of transplanting dates and density on yield response to onion (Valencianna Type). Horticultura –Argentina, 14 (37): 23-29.

Gomez, K. A and A. A. Gomez. 1984. Statistical Procedure for Agricultural Research (2nd edn.). John Willey & Sons, New York, p. 28-192.

Gupta, G. S. S and M. A. Gaffar. 1980. Effect of row spacing and effect of different combination of NPK fertilizer on the yield of onion. Bangladesh Hort., 8(2): 8-12.

Hassan, M. S. 1978. Effect of plant population densities on yield of onion in the Sudan Gazira. Acta Hort., 84: 85-90.

Hedge, D. M. 1988. Effect of irrigation nitrogen fertilization on yield, quality, nutrient uptake and water use of onion (*Allium cepa* L.). Singapore J.Pri. Ind., 16(2): 111-123.

Hossain, A. K. M. and A. M. J. Islam. 1994. Status of Allium production in Bangladesh. Acta Hort., 358: 33-36.

Islam, M. T. and M. A. Haque. 1977. Effect of nitrogen, Phosphorus and Potash on the yield of onion. Bangladesh Hort., 5 (1): 5-8.

Jones, H. A. and L. K. Mann. 1963. Onion and their allies. Leonard Hill (books) Ltd. London. P. 32.

Katwale, T. R. and R. K. Saraf. 1994. Studies on response of onion to varying levels of fertilizer doses during Monsoon season in Satpura Plateau. Orissa J. Hort., 22 (1-2): 13-18.

Khandelwal, R. C. and R. C. Maiti. 1971. Effect of planting distance in onion bulbs for seed production. Ragasthan Agriculturist, 10/11: 18-20.

Khushk. A. M. Miano, A. H. Ansari and M.I. Mari. 1990. Influence of inter and intra row spacing on the yield and the yield components on onion (*Allium cepa L.*). Sarhad J. Agric., 69 (2): 147-150.

L'Hermite, P., P. Sequi and J.H. Voorburg. 1993. Scientific basis for environmentally safe and efficient management of livestock farming: Report of the Scientific Committee of the European Conference Environment, Agriculture and Stock Farming in Europe, Mantova 1991-1992. Mantua Italy, European, Conference.

Laughlin, J. C. 1988. Nutritional effect on onion yield and quality. Acta Hort., 247: 211-215.

Lazo, F. D., A. Queddeng and C.M. Caliwag. 1969. The effect on varying amounts of commercial fertilizers on the yield of Granex onion. Philipp. J. Plant Ind., 34: 39-44.

Lopes, J. F. 1987. Effect on Planting dates and spacing on several characteristics of short day onion varities grown in south Texas. Disst. Abst. Intl., 48 (6: 1564.

Madan, S. P. S and J.S. Sandhu. 1985. Influence of nitrogen phosphorus and potash level on the growth of bulb yield and dry matter production of white onion variety. Punjub Vegetable Growers, 20:1764.

Maier, N. A., A. P. Dahlenburg and T.K. Twigder. 1990. Effect of nitrogen on the yield and quality of irrigated onions (*Allimu cepa* L.) cv.Cream Gold on silicecus sands. Australia J. Hort., 30(6): 845-851.

Mannan, M. A. 1997. Effect of water regimes on physio-morphological charcters and yield of cabbage. Ph. D. Programme, Department of Horticulture, BAU, Mymensingh.

Mehla, C. P., K. S. Baswana, B. S. Saharan and J. S. Taya. 1993. Effect of row spacing and nitrogen levels on growth and yield of onion. Prog. Hort., 25(3-4).

Misra, N. M. and K. Prasad. 1966. Effect of sulphur fertilization on yield of onion. Fertil. News, 11(10).

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

Mondal, M. F. J. L. Brewster, F. E. L. Morris and H. A. Butler. 1986. Bulb development in onion (*Allium cepa* L.). Effect of plant density and sowing date in field conditions. Ann. Bot., 58(2):187-195.

Nasiruddin, K. M., M. F. Mondal, A. M. Farooque and M. A. Baten. 1993. Effect of potassium and sulphur on growth and yield of onion. Bangladesh J. Agril. Sci., 20(1):35-40.

Nichols, M. A. and W. Heydecker. 1964. Onion sets at four by six gave the highest returns.

Palled, Y. B., Kachapur and A. M. Chandraschkh. 1988. Response of onion to irrigation and nitrogen. Indian J. Agron., 33 (1): 22-25.

Pandey, U. B., L. Singh, R. Kumar, and S. P. Raychaudhury.1991. Response of of different levels of N, P, K on the yield and quality of Kharif oinion. Tecent Advances in Medicinal, Aromatic and Spice Crops, 1: 231-34.

Pandey, Y. B., S. Lallan, K. Raj. L. Singh and R. Kumar. 1990. Studies on the effect of dates of transplanting and levels of nitrogen on the yield and quality of onion (*Allimu cepa* L.). Newsletter Associated Agric. Dev. Foundation., 10(3):10-12.

Paterson, D. R. 1979. Sulphur fertilizer effects on tield and pungency. Progress Report. No. PR- 3551, Texas Agricultural Experiment station, P-2.

Rahman, M. M. and A. H. M. Faruque. 1975. Effect of different doses of NPK on the yield on onion (*Allium cepa L.*). Bangladesh Hort., 3(1): 41-44.

Rahim, M. A., 1992. Spices and plantation crop in national ecomny. Proc. Sixth National Horticulture Convention and symposium held at BAU during 16-17 April 1992. p. 24-29.

Rahim, M. A., A. Husain and M. A. Siddque. 1992. Production of bulb and storage ability of three cultivars of onion. The Punjab Vegetable Grower, 17-18: 13-20.

Rahman S. M. R. Talukder and A. M. Miah. 1976. Effect of different doses of NPK on the yield of onion (*Allium cepa*). Bangladesh Hort., 3(1): 41-44.

Rajas, R. N., S. N. Ghulaxe and S. R. Tayde. 1993. Effects of varying levels of sulphur and spacing compared with frequencies of irrigation on yield of onion grown in Vidarbha. J. Soils Crops, 3(1): 37-40.

Rashid, M. A. and M. M. Rashid. 1976. Effect of spacing on the yield of onion. Bangladesh Hort., 4(2):18-22.

Rashid, M. M. 1983. Shabjir Chash (in Bnagla). Begum Shaila Rashid, BARI, Residential Atrs, Joydebpur, Gazipur, p. 185.

Rizk, F. A. 1997. Productivity of onion plant (*Allum cepa*) as affected by method of planting and NPK application. Egyptian J. Hort. 24, (2): 219-238.

Rizk. T. Y., M. T. Fayed, S. M. El-Nagar and H. Fawzy. 1991. Effect of plant spacing on weeds, growth, yield and its components of onion (*Allium cepa*) Egyptian J.Agron., Special issue L 71-80.

Sattar, M. A. M. A. Haque. 1975. Effect of different levels of Nitrogen and Potash on the yield of onion (*Allium cepa*) Bangladesh Hort., 3(2): 33-36.

Sharma, R. P. 1992. Effects of planting materials, nitrogen and potash on bulb yields of rainy season onion (*Allium cepa* L.). Indran J. Agron., 37(4):868-869.

Singh, H., S. Singh and V. Singh. 1996. Response of onion (*Allium cepa*) to nitrogen and sulphur. Ann. Agric. Res., 17(4); 441-444.

Singh, J. and B. S. Dhankhar. 1988. Effect of nitrogen, potash and zinc on growth, yield and quality of onion. Indian Agric., 32(3): 163-170.

Singh, P. P. 1972. Effect of nitrogen, spacing and clipping of seedling on the yield of onion. (*Allium cepa*). Indian. J. Agril. Res., 6(3): 221-224.

Singh, R. V. 1995. Response of onion to plant spacing and nitrogen and phosphorus fertilization. Res. J. Birsa –Agril .Univ., 7 (2): 141-143.

Singh, T., S. B. Singh and B. N. Singh. 1988. Effect of nitrogen, potassium and green manure on growth and yield of rainy season onion (*Allium cepa*) Narindra Deva J. Agric. Res., 4(1): 57-60.

Singh, U. V. 1987. Note on the effect of NP and K on yield of onion. Plant Sci. 10: 159-161.

Smittle, D. A. 1984. Response of onions to sulphur and nitrogen fertilization. Res. Expt. Stat., Georgia, 455: 10.

Soto, J. A. 1988. Nutritional requirements of onion (*Allium cepa*) in the soils of Northern Cartago. Critical leaves for PK and S and response to N Agron Costarricense, 12(1):53-57.

Sotffela, P. J. 1996. Panting arrangement and density of transplants influence Sweet Spanish onion yields and bulb size. Hort. Sci., 31(7): 1129-1130.

SRDI, 2005. Survey of Agro ecological Zone (AEZ) no. 3. Rangpur. P. 13.

Vacchani, M. U. and Z. G. Patel. 1993. Growth and yield of onion (*Allium cepa*) as influenced by nitrogen, phosphurs and potash under South Gujrat condition. Prog. Hort., 25 (3-4): 166-167.

Verma, J. P., Rathore and V. Ram. 1972. Effect of level of nitrogen and spacing on the performance of bulb crop of onion (*Allium cepa*). Prog. Hort., 4(1):57-68.

Vik. J. 1972. The effect of plant spacing, plastic tunnels and row distance on total yield, size, keeping quality and skin color of direct seeded onions on experiments at Landvik 1967-69.