INFLUENCE OF EARTHING UP ON GROWTH AND YIELD OF JAPANESE BUNCH ONION LINES

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CERTIFICATE

This is to certify that the thesis entitled “Influence of Earthing Up on Growth and Yield of Japanese Bunch Onion Lines” submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of Master of Science in Horticulture, embodies the result of a piece of bona fide research work carried out by Md. Faisal Mahmud, Registration No. 06-02080 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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ABSTRACT

The study was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2011 to May 2012. The experiment consisted of two factors:

Factor A: Japanese bunch onion lines as L1: White star, L2: Moto kura and L3: Akahige or Red hero; and Factor B: Earthing up as E0: No earthing up (control), E1: Once earthing up and E2: Twice earthing up. The two factorial experiment was laid out in a Randomized Complete Block Design with three replications. Significant variation was recorded for most of the studied parameter for different Japanese bunch onion lines and earthing up and also their interaction effect. The tallest plant (60.7 cm) and the highest yield (14.3 t/ha) were found from L2, whereas the lowest was recorded from L3. For earthing up, the tallest plant (60.4 cm) and the highest yield (14.4 t/ha) were observed from E2, again the lowest value was recorded from E0. In case of interaction effect, the tallest plant (62.9 cm) and the highest yield (15.3 t/ha) were observed from L2E2, while the lowest was recorded from L3E0. Moto kura with twice earthing up was found more suitable for Japanese bunch onion cultivation in the studied agro-climate.

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CHAPTER I

INTRODUCTION

Welsh onion or Negi or Japanese bunch onion (Allium fistulosum L.) is a perennial onion belongs to the family Ameryllidaceae (Fritsch and Friesen, 2002). It reached Japan before 500 AD and spread further South-East Asia and Europe. Japanese bunch onion is one of the most important vegetable crops in eastern Asia, especially in Japan, Korea, and China (Inden and Asahira, 1990). It is a perennial plant, grown commercially as an annual or a biennial, and usually propagated by seed. According to Yakuwa (2006) there are basically two types of A. fistulosum in Japan: Nebuka-negi (white-leaf sheath type) and Ha-negi (green-leaf type). It was originated in Siberia, and is very popular in the East where it is known as Japanese leek. Japanese bunch onion is one of most popular vegetables in temperate Asia and can be grown in subtropical region; since it has some highly cold tolerant cultivars and other highly heat tolerant ones.

Negi's growth is vigorous in spring and autumn and retards in summer and winter (Mansour, 1990). Negi or bunch onions can be easily grown in any kind of well drained and organic matter rich soil (Maryati and Soni, 2011). The production of Negi seedling is similar to onion. It is a new crop in Bangladesh and as it is similar to the onion in taste and flavor so it can be used as alternatives of onion. The nutritional composition of raw green tops per 100 g edible portion is: Water 90.5 g, energy 142 kj, protein 1.9 g, fat 0.4 g, carbohydrate 6.5 g, Ca 18 mg, Mg 23 mg, P 49 mg, Fe 1.2 mg, Zn 0.52 mg, vitamin A 1160 IU, thiamin 0.05 mg, riboflavin 0.09 mg, niacin 0.40 mg, foliate 16 µg, ascorbic acid 27 mg (USDA, 2002). A large proportion of the storage carbohydrates are sugars and oligosaccharides. Besides glucose, fructose and sucrose, they consist of maltose, rhamnose, galactose, arabinose, mannose and xylose and sugar and protein contents also increase in Negi plants grown under low temperature and this improves eating quality.

The advantages of Japanese bunch onion cultivation are its high resistance to low temperatures, little soil nutrient requirements (Yamasaki et al., 2003, Su et al., 2007), high nutritive value and unique flavour (Laziæ et al., 2002, Stainer et al., 2006, Tendaj and Mysiak 2007). According to Kotlinska and Kojima (2000) and Higashio et al., (2007), Japanese bunch onion is particularly abundant in vitamin C, but also contains other valuable compounds such as carotenoids, macro and micronutrients, especially Ca and K, as well as flavonoids, which are potent antioxidants (Mysiak and Tendaj, 2008). Normally, leaf blades contain more vitamin C, carotenoids, vitamins B1, B2, niacin and minerals than the pseudo stem (Warade and Shinde, 1998). The specific odour of the crop is attributed to volatile allyl sulphides.

In the Eastern Asia, where bunch onion receives considerable attention, many cultivars are available for different latitudes and climatic conditions (Rubatzky and Yamaguchi, 1997). In Poland, a local population called ‘Siedmiolatka’ is widely grown in home gardens (Tendaj and Mysiak, 2011). Lately however, two new cultivars called ‘Kroll’ and ‘Wita’ have been developed. Bejo Zaden, a Dutch seed company, has recently developed some pseudostem type cultivars producing few tillers, which can be grown for the use of whole plants in early stages of the growth (Kotlinska et al., 2005). The cultivars Parade and Performer belong to this type of cultivars and, having a short growing period, they may be considered as an alternative green bunch onion to bulb onion normally used for this purpose (Grevsen, 1989). Different line of Negi have different yield potentiality and these lines respond differently to input supply, cultivation practices and the prevailing environment during the growing season. BARI onion 2 and BARI onion 3 are suited for cultivation during kharif season. The rest of the varieties are generally cultivated mostly in winter season.

Earthing up or ridging is the technique in agriculture and horticulture of piling soil up around the base of a plant. Hilling buries the normally above-ground part of the plant, promoting desire growth. Hilling may also be used to stabilize the stems of crops which are easily disturbed by wind. Earthing up of soil to the base of the Negi plant may increase the length and diameter of the underground portion of the plant and increased the length which is an indication of better quality and higher yield. Kumar and Gowda (2010) reported that yield of the crop responded significantly due to earthing up. Earthing up provided the maximum number of tuber with large size (Tesfaye et al., 2013). Mukherjee et al. (2012) reported that earthing up is an economically viable weed control practice.

Considering the above mentioned facts and based on the prior observation, an investigation was undertaken with the following objectives:

* To determine the suitable line of Japanese bunch onion in context of Bangladesh climatic condition;
* To determine the influence of earthing up on the yield of Japanese bunch onion.

CHAPTER II
REVIEW OF LITERATURE

Japanese bunch onion or Negi is a new crop in Bangladesh and different factors influence the growth and yield of this crop. Different line of Negi have different yield potentiality and these lines respond differently to input supply, cultivation practices and the prevailing environment during the growing season. Earthing up of soil to the base of the Negi plant may increase the length and diameter of the underground portion of the plant and increased the length which is an indication of better quality and higher yield. So it is important to assess the effect of different lines and earthing up for the best growth and yield of Japanese bunch onion. The work so far done in home and abroad in these aspects reviewed in this chapter under the following headings:

2.1 Japanese bunch onion

Welsh onion or Negi or Japanese bunch onion (A. fistulosum) is a perennial onion other names that may be applied to this plant include Green onion, Spring onion, Scallion and Salad onion which comes from family Ameryllidaceae. No wild forms are known in A. fistulosum, which was differentiated into major cultivar groups already in ancient China.

It reached Japan before 500 AD and spread further South-East Asia and Europe. The onion originated in Siberia, and is very popular in the East but it is grown in most regions of the world (Rabinowitch and Currah, 2002).
Japanese bunch onion is one of most popular vegetables in temperate Asia and can be grown in subtropical region; since it has some highly cold tolerant cultivars and other highly heat tolerant ones. Its growth is vigorous in spring and autumn and retards in summer and winter (Tendaj and Mysiak, 2007). It does not have a long day dormant stage like A. cepa. Superficially, there is a strong resemblance to A. cepa but it doesn’t develop bulb although some slight thickening of the pseudo stem may occur and possess hollow leaves and scales. Its foliage leaves are somewhat rounder in cross section, not flattened. Differences are more prominent in the flower seen A. fistulosum flowering progress from the top of umbel downwards. The lateral buds in the axils elongate and develop as tillers to form a dump. It can be propagated by vegetative means; it is usually propagated through seed and grown as an annual or biennial crop.
Negi or Bunch onions grown successfully in any kind of well drained and organic matter rich soil and the common practice are to use seed for propagation to enhance the blanched part of the pseudo stem. Plants with green leaves can be harvested 2-3 month after transplanting, but it may take 6 to 9 months before plants are ready to harvest for blanched pseudo stems (Rubatzky and Yamaguchi, 1997). Raising soil to the base of the Negi plant may increase the length and diameter of the underground portion of the plant and increased the length which is an indication of better quality and higher yield. Under favourable weather conditions, Japanese bunch onion also may be grown all year round for the production of green tops (Inden and Asahira, 1990).
Onion is a kind of spice crop. It is a most widely used as spice crop in Bangladesh. Onion is a most important element in our food menu. Of all the spices, it is widely used. In Bangladesh, it is generally used as a spice but in developed countries it is used as a vegetable and salad mostly. In every year, there are about 1.5 lac hectors of land are used for onion cultivation. It only fulfill one third of the demand, we have to depend on the adjacent/neighboring countries. Besides, onion is cultivated only in the winter season. So we have to buy onion at a high price for the rest of the year. In developed countries, it is seen that, Negi (A. fistulosum)/Bunch onion is widely used adjacent to onion to reduce the pressure on onion. Bunch onion is leafy which is exactly similar to onion in taste and smell. There is no deficit in taste if cooking is done with Negi instead of onion. Rather the smell of leafy Negi creates a delicious atmosphere. The specific odour of the crop is attributed to volatile allyl sulphides (Warade and Shinde, 1998).
Negi or bunch onion is grown well in any kind of well drained soil. It gives good yield in that soil which is rich in organic matter. The production of Negi seedling is similar to onion. At first, seeds are sown in the seedbed and then the seedlings are transplant to the main field. It may also cultivate in the main field by sowing the seeds directly in the line. The common practice is to use seed propagated transplants in order to shorten a long growth period and to enhance the blanched part of the pseudo stem. Plants with green leaves can be harvested 2-3 month after transplanting, but it may take 6 to 9 months before plants are ready to harvest for blanched pseudo stems (Rubatzky and Yamaguchi,

1997). The distance between line to line may be 15-10cm and plant to plant may be 5 cm. 250 kg fertilizer/ha (Urea : TSP : MP = 1:2:2) have to be properly mixed with the soil during land preparation. When Negi becomes 2-3 weeks older, 20-25 kg urea may be applied as top dressing. Two weeks earlier before harvesting, soil should be earthen up at the base of Negi plant. It makes the stem of Negi plant long and strong. In Rabi season, irrigation should be given at 7-10 days interval. There is no need for irrigation during Kharif season. But in rainy season, the drainage system of the field should be well developed.

The infestation of downy mildew is seen when Negi is produced during the Rabi season. Ridomil gold or Dithane M-45 may be applied 2-3 weeks earlier before harvesting or it may be sprayed at the seedling stage. If proper measures are taken, then the outbreak of disease may not be seen.

The advantages of Japanese bunch onion are its high resistance to low temperatures, little soil requirements (Kotlinska and Kojima, 2000; Yamasaki et al., 2003). It is its resistance to many diseases and pests of bulb onion, including pink root (Martinez, 2005).

Japanese bunch onion have a mild favor, which is not too strong as of garlic or Chinese chive. Its raw chopped leaves, especially soft green leaves, are good as a seasonal light taste Japanese foods. Cooking destroys its pungency and as a result, enhance its sweet flavor. Its etiolated pseudo-stem is good for various kinds of foods (Kolota et al., 2010).

The product is mainly used as an additive to preprocessed food such as instant noodles. The young inflorescence is sometimes deep-fried and eaten as a snack. The rapic qualities attributed to A. fistulosum are many, especially in Chinese medicine for the prevention of cardiovascular disorders, and to prolong life. It is further reported to improve eyesight, and to enhance recovery from common colds, headaches, wounds etc. The nutritional composition of raw green tops per 100g edible portion is: Water 90.5 g, energy 142 kcal, protein 1.9 g, fat 0.4 g, carbohydrate 6.5 g, Ca 18 mg, Mg 23 mg, P 49 mg, Fe 1.2 mg, Zn 0.52 mg, Vitamin A 1160 IU, thiamin 0.05mg, riboflavin 0.09 mg, niacin 0.40 mg, foliate 16 µg, ascorbic acid 27 mg (USDA, 2002). A large proportion of the storage carbohydrates are sugars and oligosaccharides. Besides glucose, fructose and sucrose, they consist of maltose, rhamnose, galactose, arabinose, mannose and xylose.

In a study comprising of two field experiments conducted by Eugeniusz et al. (2012) to evaluate yield and nutritional value of Japanese bunch onion (A. fistulosum L.) depending on the growing season and plant maturation stage an they recorded highest plant height 53.1 cm, maximum number of leaves 5.7 and highest marketable yield 16.14 ton from the seeds of the cultivar Performer Japanese bunch onion.

2.2 Different lines/variety on yield contributing characters and yield

For the development of a palatable cultivar and appropriate sales strategies, research into preferences of Japanese bunch onion (welsh onion) among general consumers and various types of restaurants were carried out by Miyagi et al. (2011). Research methods involved a distribution table for the general consumer and individual interviews for restaurants. For the general consumer, stronger flavor and sweetness of fresh and heated (boiled or grilled) bunch onions were preferred. Softer texture of grilled bunch onion was also preferred. Preferences regarding pungency, stickiness and texture for fresh, boiled and grilled Japanese bunch onions varied depending on the consumer's individual attributes.

For restaurants, softer pungency and stronger sweetness of Japanese bunch onions were preferred, while preferences for flavor and texture varied according to the restaurant type. Freshness and domestic production were considered important items when restaurant owners choose Japanese bunch onions. Japanese food restaurants tended to value taste and flavor, while other types of restaurants tended consider the price and size of Japanese bunch onion important. In the demand for the Japanese bunch onion breeding, the Japanese food restaurant owners frequently expressed hope for the development of Japanese bunch onion cultivar with specific features, while other restaurants hoped for improvement of its appearance, price and stable quality.

An experiment was conducted by Hikaru et al. (2010) to investigated the correspondence between classifications based on simple sequence repeat (SSR) markers and on morphological traits for 30 bunch onion (A. fistulosum L.) varieties. They also examined applicability of an assignment test for variety identification in bunch onion. Although ‘Iwatsuki-2’ has been regarded as a member of ‘Kaga’ group, molecular data suggested the variety belonging to ‘Kujo’ rather than ‘Kaga’. In the assignment test at the individual level, 89.1% of the individuals were assigned to their original variety. When the assignment was conducted based on groups each consisting of four individuals, the percentage of correct assignments was considerably improved (99.3%). These results suggested that the assignment test approach will be useful for variety identification in allogamous bunch onions, which have large within-variety genetic diversity. On the other hand, it was also suggested that sampling of true source varieties will be fundamental to avoid misjudgment.

Yamashita and Tashiro (2004) conducted a study, to developed male sterile lines of Japanese bunch onion (A. fistulosum) possessing the cytoplasm of a wild species, A. galanthum, by backcrossing. To evaluate seed productivity of the male sterile lines in practice, they were crossed with the male fertile line, cultivar Kujyo, using honeybees as pollinators under field conditions. The number of florets and seeds per inflorescence, seed set and seed germination of the material were investigated. Although variation was observed among the male sterile lines, there were several lines having seed productivity equal to cultivar Kujyo.

Nine virus-free clones (Hiroshima-1 go-Hiroshima 9 go) of wakegi onion (A. wakegi) were examined by Araki et al. (2003) fluorescent amplified fragment length polymorphism (AFLP) technique using 16 primer combinations. Twelve out of the 16 primer combinations amplified a total of 678 DNA fragments (peaks) in nine wakegi onion clones. Eight primer combinations produced 11 polymorphic markers available for discriminating the nine clones from each other, except between Hiroshima-1 and Hiroshima-2 go ('Kanshirazu'). The AFLP data revealed that 26.3% and 23.5% of the 678 DNA fragments were derived from Japanese bunch onion (A. fistulosum) and shallot, respectively. Five, out of 11 polymorphic markers, were seemingly originated from Japanese bunch onion, whereas three were from shallot. The results verified that wakegi onion are interspecific hybrids whose parents are the Japanese bunch onion and shallot.

To prevent bolting and to develop a new cropping system for harvest in June, the effects of tunnel covering and a 16-h photoperiod (LD) on the growth, flower initiation and bolting of Japanese bunch onion (A.

fistulosum) cultivars Kincho, Asagi-kujo and Cho-etsu were investigated by Yamasaki et al. (2003). The maximum air temperature was 20-250C higher under the tunnel than in the open field. Growth during the treatments was accelerated by tunnel covering and LD, solely or combined. With Cho-etsu, tunnel covering alone effectively prevented bolting, because devernalization was induced by a high day temperature, but with Kincho and Asagi-kujo, it did not. However, when tunnel covering was combined with LD, the bolting rate was decreased to 7-24%. The inhibitory effect of LD alone on the bolting rate was not observed for Kincho and Asagi-kujo. However, with Cho-etsu, LD alone sufficiently prevented bolting; when combined, LD and tunnel covering prevented bolting completely. These results indicate that the 16-h photoperiod induced devernalization of Japanese bunch onion. The possibility of harvesting some mid-season cultivars, such as Kincho and Asagi-kujo in June was successfully established. As the bolting rate did not correspond to the developmental stage of flower buds during the treatments in Asagi-kujo, abortion of developing flower buds may be induced by high day temperature.

At the Warmenhuizen (the Netherlands) open day the vegetable breeder Bejo presented the new onion varieties BGS180, Hytech, BGS162, and BGS173. For BGS180 a high yield and good storage quality is reported by Kretschmer (2002). Hytech is an early, high yielding, round type. BGS162 has a good internal and external red colour and can be stored until March. BGS173 is a bunch onion with a very long white stem. Results from the third year of an organic variety test plot indicated good results for Hyfort, Hystar, Hytech and Renate. The bulbs are available in organic quality. At the Oudkarspel (the Netherlands) open day the breeding house Cause/Tezier presented the new bunch onion variety Cristobal, suitable for protected, plastic tunnel and field production. Cristobal is from the A. fistulosum gene pool, the main onion in China and Japan. The cultivation time is 90-120 days and 25×2.5 cm spacing is recommended.

Yamasaki and Tanaka (2002) conducted an experiment to find out the effect of root zone temperature on bolting of Japanese bunch onion (A. fistulosum) was investigated using a root zone temperature controlling apparatus. High root zone temperature promoted the growth of three cultivars, Kincho, Asagi-kujo and Cho-etsu irrespective of the air temperature conditions. High root zone temperature of 5-200C under a low air temperature inhibited the bolting of three cultivars. In contrast, low root zone temperature of 5-150C under a high air temperature promoted the bolting of Kincho and Asagi-kujo. The importance of root zone temperature in flower initiation of Japanese bunch onion is presented.

The relationship between bulb shape and fresh-weight were examined by Hasegawa et al. (2001) in 6-17 phenologically different onion varieties over a period of three consecutive years (1997-2000). Cultivars recommended for production in different agricultural areas of Southwestern Japan, were classified according to their maturity in early, mid-diameter and late varieties. Onion bulb shape, expressed as the proportionality existent between the diameter and height, was lower in the early local varieties, such as Kaizuka-wase (1.8+or-0.04) and Shizuoka-wase (1.8+or-0.03), thus reflecting their flattened form. In the later varieties, such as Osakamaru and Yamaguchi-kodaka, the value was 1.1+or-0.02, demonstrating their complete globular shape. Conversely, for the F1 varieties Apollo, Advance and OL, the ratio value was higher (1.3+or-0.05) and was lower for Momiji (1.0+or-0.01). In general, they presented less oblateness than the local varieties. Among the local varieties, the highest bulb weights recorded were 365.8 and 356.9 g/bulb for Awajichyukou and Sensyu-nakate, respectively, while the remaining five cultivars weighed less than 300 g each. In contrast, with the exception of Momiji, all F1 hybrids registered weight values superior to 300 g, beginning with advance that yielded of 470 g.

To control the bolting of Japanese bunch onion (A. fistulosum) photo periodically, the effect of photoperiod before, during and after vernalization on flower initiation and development and the varietal differences were investigated by Yamasaki et al. (2000) using the two mid-season flowering cultivars Kincho and Asagi-kujo, and a late-season flowering cv. Cho-etsu. A long-day photoperiod (LD, 16 h) given before vernalization inhibited flower initiation. Especially, the bolting rate of Asagi-kujo decreased by about a half, compared with the short-day photoperiod (SD, 8 h). The interaction between the effect of night temperature (30C, 70C, 110C or 150C) and the effect of the photoperiod (SD and LD) during vernalization was also investigated. In Kincho, LD did not affect flower initiation at 30C, but inhibited flower initiation at 70C, 110C and 150C. In Asagi-kujo, flower initiation was significantly inhibited by LD under all temperature conditions. This inhibitory effect was stronger at 110C and 150C than at 30C and 70C. In Cho-etsu, LD significantly inhibited flower initiation at 30C and 70C, and flower initiation rarely occurred at 110C and 150C. In this study, generally, LD during vernalization inhibited flower initiation in all cultivars. Thus Japanese bunch onion required a short-day photoperiod in flower initiation, which was stronger in Asagi-kujo and Cho-etsu than in Kincho. From these results, we conclude that low temperature and a short-day photoperiod complementarily induce flower initiation in Japanese bunch onion. After flower initiation, the early stage of flower development is day-neutral, and after the floret formation stage, a long-day photoperiod promotes flower development and elongation of the seed stalk.

Varieties of Japanese bunch onion include White Spear, Evergreen, Kujo (Kujyo) Multistalk, ishikura Long, He-shi-ko, Nebuka, Kincho, Red Beard, Tsukuba (a heat-resistant variety grown in spring for summer use), Multi-Stalk, and Tokyo Long White. In Japan, thick-bladed types are also grown. Among the popular varieties are Kaga, Shimonita, Senju, and Kuronobori. Hybrids with the common onion (A. cepa) include White Knight and Beltsville bunch. This onion does not form a bulb. It grows in clumps with several tillers bunched together. The stalks are silvery white and about % inch in diameter. Depending on the variety, they will grow 6 to 24 inches long (Rubatzky and Yamaguchi, 1997).

2.3 Earthing up on yield contributing characters and yield

An experiment was conducted by Tesfaye et al. (2013) to investigate the effect of plant spacing and time of earthing up on tuber quality of Jalene potato variety four levels of plant spacing (10, 20, 30 and 40 cm) and four times of earthing (15, 30, 45 days after plant emergence and no earthing). Significantly the highest number of green potatoes (41 tubers/plot) was observed at the interaction of 10 cm with no earthing up whereas the highest number of large tubers (6 tubers/hill) was found at the interaction of 40 cm with earthing up after 15 days.

Mukherjee et al. (2012) conducted an experiment in West Bengal, India, during the 2006 and 2007 rabi seasons, to determine suitable and economically viable weed control practices for potato cv. Kufri Jyoti. The treatments comprised 0.30 kg metribuzin/ha at 7 days after planting (DAP) as early post-emergence in ridge planted potato, followed by earthing up at 45 DAP, 50 kg metribuzin/ha at 7 DAP in ridge planted potato, followed by earthing up at 45 DAP, 0.60 kg pendimethalin/ha as pre-emergence in ridge planted potato, followed by earthing up at 45 DAP, 0.10 kg oxyfluorfen/ha as pre-emergence in ridge planted potato, followed by earthing up at 45 DAP, 0.50 kg isoproturon/ha as pre-emergence in ridge planted potato, followed by earthing up at 45 DAP, 0.50 kg paraquat/ha as early post-emergence at 2-3% emergence of potatoes (10 DAP) in ridge planted potato, followed by earthing up at 45 DAP, mulching with rice straw at 10 t/ha after planting of potato in ridges, farmer's practice (flat bed planting with 2 hand weedings at 15 and 30 DAP and earthing up at 45 DAP), weedy control and weed-free control.

The field studies were conducted by Aslam et al. (2008) on management strategies for controlling lodging in pre-sown sugarcane at Sugarcane Research Station, Khanpur during 2004-05 and 2005-06. The management practices included two sowing techniques i.e., Shallow furrows, deep trenches and three earthing up treatments i.e., no earthing, earthing up with spade and earthing up with ridger. The results indicated non-significant cane yield improvement due to trench sowing and significant due to earthing up. Spade earthing increased cane yield by 19.20% and earthing up with ridger increased by 18.00% over no earthing control in pool analysis. A measurable increase in commercial cane sugar was record owing to earthing up as a result of reduced lodging.

Field trials on turmeric (Curcuma longa L.) was conducted by Jage et al. (2006) to find out the best method and optimum level of potassium on loamy soils of North-Eastern Haryana. Split application of potash (K), half at planting and half at earthing up gave the highest rhizome yield (257.4 q/ha) and was found significantly better than the application of K fully at planting (241.7 q/ha) or at earthing up (228.0 q/ha). In terms of the rhizome yield, the crop responded significantly up to application of 50 kg K20/ha. Interaction between method and level of K application was found significant in respect of the rhizome yield during 2002-03 which revealed that the crop required only 25 kg K_2O/ha if K was applied in two equal splits at planting and earthing up.

A field experiment was conducted by Chettri et al. (2006) in clay loam soil to study the effect of agro-mechanical techniques on straightness of the cane. Two tillage techniques, i.e., deep cultivation (DC), 22-25 cm deep, along with earthing up and traditional shallow cultivation (SC), 12-15 cm deep, were compared for two cane varieties, 'CP-65/357' and 'L-62/96'. No significant difference in straightness of cane was observed and both techniques failed to produce required straight cane.

Total four experiments were carried out by Muhammad et al. (2001) in the different ecological zones of the province i.e. Southern, Northern and Central zones in order to find out the suitable time of earthing up for obtaining maximum yield of sunflower crop in NWFP. The average data of four locations revealed that sunflower gave highest yield if the earthing up is completed before bud formation. However, seed yield is decreased when earthing up is delayed. It is, therefore, recommended that earthing up before bud formation is necessary for obtaining higher returns from sunflower with respect to seed yield.

Dua (2000) conducted an experiment with treatments consisted of a combination of 4 fertilizer levels and 4 weed control methods (control; manual weeding + earthing up; 1.5 kg alachlor/ha (pre-emergence); and 0.5 kg paraquat/ha. Paraquat, alachlor and manual weeding + earthing up treatments gave 61.3, 47.3 and 36.2% higher tuber yields, respectively, compared to the control.

Sarwar et al. (2000) reported from an experiment that mean cane yield (186.9 t) was highest with earthing-up with tractor mounted cane ridger, followed by 177.6 ton with deep tillage by a sub soiler. The commercial cane sugar content increased was highest with earthing-up by ridger (14.09%).

Sharma et al. (2000) conducted an experiment with 3 levels of intercultural viz., no intercultural, one hoeing at 15 days after sowing (DAS) and earthing up at 30 DAS along with 5 treatments of atrazine viz., no atrazine (control), and pre- or post-emergence application of atrazine at 1 kg/ha by spraying or mixing with sand. Earthing up at 30 DAS resulted in the virtual elimination of weeds throughout the crop growth period but there was no additional increase in yield when earthing up was added.

An experiment was conducted by Qadir et al. (1998) on the growth and yield of potato cv. "Ultimus" as affected by earthing-up was conducted at Agricultural Research Institute, Tarnab, Peshawar, Pakistan. Earthing-up at different stages of growth were applied. Earthing-up two weeks after the completion of tuber emergence was found the best in terms of maximum plant height (48.37 cm), plant spread (47.50 cm), number of stem per plant (5.02) and tuber per plant (11.00) and yield per hectare (12.32 tons/ha) were noted for this treatment.

An experiment were conducted by Bisen and Barholia (1990) at Chhindwara to find out the effects of 80 or 120 kg N/ha at planting, 40 + 40 or 60 + 60 kg at planting and earthing up, 40 + 20 or 60 + 40 kg at planting and earthing up + 20 kg N as 2 foliar sprays or no N fertilizer on yield of potatoes cv. Kufri Sindhuri. 40 kg N at planting + 20 kg at earthing up + 20 kg as 2 foliar sprays gave the highest average yield of 26.0 t/ha followed by 120 kg N at planting (25.4 t) compared with no N (16.8 t). All treatments gave higher yields than the control. plant stands were highest with 80 kg N at planting.

Unirrigated potato (Solanum tuberosum L.) cv 'Local Red' was evaluated by Shrestha et al. (1981) for emergence, tuber number and tuber weight per hill, and yield per hectare with respect to planting methods, number of sprouts, and earthing-up. Furrow and flat methods were superior to ridge planting for emergence and tuber number, but tuber weight per hill was highly significant in the ridge planting (0.70 kg/hill). The tuber number following earthing-up in the ridge planted crop was low. Interactions of methods × earthing-up, and methods × sprouts number × earthing-up were significant on tuber number per hill. Significant effect on yield was also recorded in the interactions of methods × earthing-up and reported that the seed potatoes having four sprouts, planted in the furrow and earthed-up, resulted in the highest yield (25.4 t/ha).

CHAPTER III

MATERIALS AND METHODS

The experiment of Japanese bunch onion was conducted at field level during the period from December 2011 to May 2012. The materials and methods that were used and followed for conducting the experiment presented under the following sub-headings-

3.1 Experimental site

The study was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh to find out the effect of earthing up on growth and yield of different Japanese bunch onion lines.

The location of the experimental site is 23074/N latitude and 90035/E longitude and at an elevation of 8.2 m from sea level (Anon., 1989).

3.2 Characteristics of soil

Selected land of the experimental field was medium high land in nature with adequate irrigation facilities and remained utilized for crop production during the previous season. The soil is belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The soil texture of the experimental soil was sandy loam. The nutrient status of the farm soil under the experimental plot with in a depth 0-20 cm were collected and analyzed in the Soil Resources and Development Institute Dhaka, and result have been presented in Appendix I.

3.3 Climatic condition of the experimental site

Experimental field is situated in the sub-tropical climate zone, which is characterized by heavy rainfall during the months of April to September and scanty rainfall during the rest period of the year. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargaon, Dhaka and presented in Appendix II.

3.4 Planting materials

Japanese bunch onion lines were used as the test crop of this experiment and the lines were collected from Japan (Sakata Seed Company).

3.5 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Japanese bunch onion lines (three lines) as

i L1: White star
ii. L2: Moto kura
iii. L3: Akahige or Red hero

Factor B: Earthing up (three levels) as

i. E0: No earthing up (control)
ii. E1: Once earthing up
iii. E2: Twice earthing up

There were 9 (3 × 3) treatments combination such as L1E0, L1E1, L1E2, L2E0, L2E1, L2E2, L3E0, L3E1 and L3E2.

3.6 Preparation of field

The land selected for conducting the experiment was opened in the 1st week of December 2011 with a power tiller, and left exposed to the sun for a week. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil was obtained for sowing seeds of Japanese bunch onion. The experimental land was partitioned into unit plots as per treatment combination.

3.7 Design and layout of the experiment

The two factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 150.00 m2 with length 15.0 m and width 10.0 m. The total area was divided into three equal blocks. Each block was divided into 9 plots where 9 treatments combination were allotted at random. There were 27 unit plots altogether in the experiment. The size of the each plot was 2.0 m × 1.0 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.8 Seed sowing

Seeds of three Japanese bunch onion lines were sown in field on 15 December 2011 in line with maintaining the distance between line to line 20 cm and plant to plant 10 cm spacing that maintained through thinning up. Finally, 100 plants accommodated in each plot.

3.9 Application of fertilizers

Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP) were used as a source of nitrogen, phosphorous, and potassium, respectively. Fertilizers were applied 250 kg/ha (urea: TSP: MP = 1:2:2) at land preparaion. Top dressing was done with 20-25 kg urea when Negi becomes 2-3 weeks older.

3.10 Intercultural operation

After raising seedlings, various intercultural operations such as irrigation, weeding and earthing up as treatment were accomplished for better growth and development of the Negi seedlings.

3.10.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after raising of seedlings in every alternate day in the evening upto seedling establishment. Further irrigation was provided when needed. Excess water was effectively drained out at the time of heavy rain.

Figure 1. Layout of the experimental plot

3.10.2 Weeding

Weeding was done to keep the plots clean and easy aeration of soil which ultimately ensured better growth and development. The newly emerged weeds were uprooted carefully.

3.10.3 Earthing up

First earthing up was done at 14 January, 2012 after 30 days of seed sowing and 2nd earthing up was done at 29 January 2012 after 15 days of 1st earthing up.

3.11 Plant protection

Ridomil Gold was applied @ 2 ml L-1 against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly for a week after seed sowing to a week before harvesting. Furadan 10 G was also applied during final land preparation as soil insecticide.

3.12 Harvesting

Japanese bunch onion or Negi were harvested at 160 days after sowing with attained highest growth stage. Considering the observation highest growth stage was marked upto 160 days and most of the growth parameter of Negi more or less similar at 140 and 160 DAS.

3.13 Data collection

Plants were randomly selected from each unit plot for data collection in every data recording day and the plants of outer rows excluded from the random selection to avoid border effect.

3.13.1 Plant height

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest leaf and mean value was calculated. Plant height was also recorded at 20 days interval starting from 60 days of sowing upto160 days to observe the growth rate of plants. It was included the upper and below ground parts of the plant.

3.13.2 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 60 DAS to 160 DAS at 20 days interval.

3.13.3 Leaf area

Leaf area was measured by using CL 202 leaf area meter from sample leaves and expressed in cm2. Leaf area was recorded from 60 DAS to 160 DAS at 20 days interval by uprooting 5 selected plants from each unit plot for every data recording day.

3.13.4 Length of leaf

The length of leaf was measured with a meter scale from the basement of leaf to the tip of the longest leaf and mean value was calculated. Length of leaf was recorded from 60 DAS to 160 DAS at 20 days interval by uprooting 5 selected plants from each unit plot for every data recording day.

3.13.5 Length of pseudostem

The length of pseudostem was measured with a meter scale. Length of pseudostem measured from the rooting zone to the basement of leaf and mean value was calculated. Length of pseudostem was also recorded from 60 DAS to 160 DAS at 20 days interval by uprooting 5 selected plants from each unit plot for every data recording day.

3.13.6 Diameter of pseudostem

The diameter of pseudostem was measured with a Digital Caliper-515 (DC-515) of Negi plants. Diameter of pseudostem was recorded from 60 DAS to 160 DAS at 20 days interval by uprooting 5 selected plants from each unit plot for every data recording day.

3.13.7 Weight of leaves per plant

The weight of leaf was measured with a digital weighing machine from the 5 whole leaves of Negi plant and mean value was calculated. Weight of leaves was also recorded from 60 DAS to 160 DAS at 20 days interval by uprooting 5 selected plants from each unit plot for every data recording day.

3.13.8 Weight of pseudostem

The weight of pseudostem was measured with a digital weighing machine from the 5 whole stem of Negi plant and mean value was calculated. Weight of pseudostem was recorded from 60 DAS to 160 DAS at 20 days interval by uprooting 5 selected plants from each unit plot for every data recording day.

3.13.9 Yield per plot

Yield of Japanese bunch onion or Negi per plot was recorded from the whole weight of below ground part by converting total number of plants per plot and was expressed in kilogram. Yield per plot was calculated on the weight of below ground parts at 160 DAS where crop was attained at highest growth/mature stage.

3.13.10 Yield per hectare

Yield per hectare of Negi was calculated by calculating the weight of plot yield into hectare and was expressed in ton.

3.14 Statistical analyses

The data obtained for different characters were statistically analyzed to find out the significance of the difference for line and earthing up on yield and yield contributing characters of Negi. The mean values of all the recorded characters were evaluated and analysis of variance was performed by the ‘F’ (variance ratio) test. The significance of the difference among the treatment combinations of means was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was carried out to find out the influence of earthing up on growth and yield of Japanese bunch onion lines. Data on different growth and development stages were recorded on growth and yield parameter. The analyses of variance (ANOVA) of the data on different growth and yield parameters are presented in Appendix III-X. The findings of the experiment have been presented and discussed with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

Plant height varied significantly for different bunch onion lines at 60, 80, 100, 120, 140 and 160 DAS (Appendix III). Tallest plant (17.9, 30.0, 39.9, 49.5, 57.5 and 60.7 cm) was recorded from L2 (Moto kura), whereas the shortest plant (13.5, 24.5, 34.9, 44.6, 52.3 and 55.1 cm) was recorded from L3 (Akahige or Red hero) at 60, 80, 100, 120, 140 and 160 DAS (Figure 2). Plant height is a genetical character and different lines/genotypes produced different plant height on the basis of their varietal characters (Plate 1). Eugeniusz et al. (2012) reported highest plant height 53.1 cm which are similar to the findings of this experiment.

Different levels of earthing up showed significant variation on plant height of Japanese bunch onion (Appendix III). Tallest plant (17.4, 29.6, 39.9, 49.6, 56.9 and 60.4 cm) were observed from E2 (twice earthing up), which was statistically identical (16.8, 28.9, 38.6, 48.9, 56.5 and 59.5 cm) with E1 (once earthing up) but significantly varied from E0 (Figure 3). Shortest plant (13.8, 24.5, 34.9, 44.4, 52.4 and 54.3 cm) was recorded from E0 (No earthing up i.e. control).

Interaction effect of different bunch onion lines and earthing up showed significant differences on plant height (Appendix III). Tallest plant (18.7, 32.6, 43.0, 53.5, 60.4 and 62.9 cm) was observed from L2E2, while the shortest (12.3, 20.4, 30.3, 41.7, 49.7 and 52.5 cm) was recorded from L3E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 1).

4.2 Number of leaves per plant

Significant variation was recorded for number of leaves per plant for different bunch onion lines (Appendix IV). Maximum number of leaves per plant (3.36, 4.82, 5.91, 7.22, 8.16 and 8.33) was found from L2 which was statistically similar (3.22, 4.76, 5.68, 7.04, 7.93 and 8.18) with L1, while the minimum number (2.89, 4.22, 5.13, 6.27, 6.98 and 7.16) obtained from L3 at 60, 80, 100, 120, 140 and 160 DAS (Table 2). Management practices influence the number of leaves per plant but variety itself manipulated the number of leaves per plant. Eugeniusz et al. (2012) reported maximum number of leaves 5.7 from an earlier experiment

Number of leaves per plant of Japanese bunch onion showed significant variation for different level of earthing up (Appendix IV). Maximum number of leaves per plant (3.36, 4.80, 5.87, 7.04, 8.20 and 8.44) was recorded from E2, which was statistically similar (3.27, 4.69, 5.62, 7.00, 8.07 and 8.27) with E1 at 60, 80, 100, 120, 140 and 160 DAS (Table 2). On the other hand, the minimum number of leaves per plant (2.84, 4.31, 5.18, 6.49, 6.80 and 6.96) was found from E0.

Different bunch onion lines and earthing up showed significant differences for interaction effect of on number of leaves per plant (Appendix IV). Maximum number of leaves per plant (3.60, 5.47, 6.40, 7.60, 9.00 and 9.40) was attained from L2E2 and the minimum number (2.60, 3.93, 5.07, 5.87, 6.07 and 6.13) was recorded from L3E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 3).

Table 1. Interaction effect of different lines and earthing up on plant height of Japanese bunch onion

Treatment	Plant height (cm) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
L1E0	12.4 c	23.3 e	34.7 c	43.7 cd	50.7 cd	53.1 e
L1E1	18.4 a	29.4 bc	38.0 bc	49.4 ab	57.1 ab	59.9 bc
L1E2	18.7 a	29.2 bc	40.7 ab	50.9 ab	58.3 ab	61.8 ab
L2E0	16.7 ab	29.8 bc	39.7 ab	47.8 bc	56.7 ab	57.2 cd
L2E1	18.4 a	31.2 ab	39.3 abc	49.6 ab	57.4 ab	62.1 ab
L2E2	18.7 a	32.6 a	43.0 a	53.5 a	60.4 a	62.9 a
L3E0	12.3 c	20.4 f	30.3 d	41.7 d	49.7 d	52.5 e
L3E1	13.4 c	26.1 d	38.4 abc	47.8 bc	55.2 bc	56.4 d
L3E2	14.8 bc	26.9 cd	36.0 bc	44.4 cd	52.0 cd	56.4 d
LSD(0.05)	2.394	2.6522	4.309	3.909	4.270	2.651
Level of significance	0.05	0.01	0.05			

				0.05	0.05	0.05
CV(%)	8.66	5.54	6.59	4.74	5.46	5.64

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

L1: White star E0: Control (No earthing up) L2: Moto kura E1: Once earthing up L3: Akahige or Red hero E2: Twice earthing up

Table 2. Effect of different lines and earthing up on number of leaves per plant of Japanese bunch onion

Treatment	Number of leaves per plant at 60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
Japanese bunch onion lines						
L1	3.22 a	4.76 a	5.68 a	7.04 a	7.93 a	8.18 a
L2	3.36 a	4.82 a	5.91 a	7.22 a	8.16 a	8.33 a
L3	2.89 b	4.22 b	5.13 b	6.27 b	6.98 b	7.16 b
LSD(0.05)	0.202	0.214	0.234	0.214	0.363	0.397
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Earthing up						
E0	2.84 b	4.31 b	5.18 b	6.49 b	6.80 b	6.96 b
E1	3.27 a	4.69 a	5.62 a	7.00 a	8.07 a	8.27 a
E2	3.36 a	4.80 a	5.87 a	7.04 a	8.20 a	8.44 a
LSD(0.05)	0.202	0.214	0.234	0.214	0.363	0.397
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.43	4.67	5.22	6.14	4.72	5.04

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

L1: White star E0: Control (No earthing up) L2: Moto kura E1: Once earthing up L3: Akahige or Red hero E2: Twice earthing up

Table 3. Interaction effect of different lines and earthing up on number of leaves per plant of Japanese bunch onion

Treatment	Number of leaves per plant at 60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
L1E0	3.00 c	4.47 cd	5.00 c	6.93 cd	7.07 d	7.27 c
L1E1	3.27 abc	4.67 c	5.87 b	7.07 bc	7.73 cd	7.87 bc
L1E2	3.40 ab	5.13 ab	6.00 ab	7.13 bc	8.33 bc	8.40 b
L2E0	2.93 cd	3.93 e	5.40 c	6.67 de	7.27 d	7.47 c
L2E1	3.53 a	5.07 b	5.93 b	7.40 ab	8.87 ab	9.13 a
L2E2	3.60 a	5.47 a	6.40 a	7.60 a	9.00 a	9.40 a
L3E0	2.60 d	3.93 e	5.07 c	5.87 f	6.07 e	6.13 d
L3E1	2.93 cd	4.53 cd	5.13 c	6.53 e	7.60 d	7.80 bc
L3E2	3.13 bc	4.20 de	5.20 c	6.40 e	7.27 d	7.53 c
LSD(0.05)	0.351	0.371	0.406	0.371	0.629	0.688
Level of significance	0.05	0.01	0.01	0.05	0.01	0.01
CV(%)	6.43	4.67	5.22	6.14	4.72	5.04

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

L1: White star E0: Control (No earthing up) L2: Moto kura E1: Once earthing up L3: Akahige or Red hero E2: Twice earthing up

4.3 Leaf area

Different bunch onion lines showed significant differences in terms of leaf area (Appendix V). Highest leaf area (84.9, 128.7, 187.7, 260.1, 324.0 and 333.0 cm^2) was observed from L2 which was statistically identical (83.0, 125.3, 184.6, 256.1 , 319.3 and 329.2 cm^2) with L1, again the lowest leaf area (75.7, 112.8, 164.5, 222.4 , 271.6 and 300.0 cm^2) was recorded from L3 at 60, 80, 100, 120, 140 and 160 DAS (Table 4).

Significant difference was recorded for different level of earthing up on leaf area of Japanese bunch onion (Appendix V). Highest leaf area (86.9, 127.8, 184.2, 256.8, 324.4 and 334.7 cm2) was found from E2, which was statistically identical (84.4, 123.9, 182.4, 255.1, 320.0 and 330.2 cm2) with E1, whereas the lowest leaf area (72.4, 115.1, 170.2, 226.8, 270.5 and 297.4 cm2) from E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 4).
Leaf area showed significant differences due to the interaction effect of different bunch onion lines and earthing up (Appendix V). Highest leaf area (94.4, 133.2, 194.6, 275.1, 352.9 and 352.5 cm2) was recorded from L2E2, again the lowest leaf area (68.7, 101.9, 143.7, 200.0, 240.1 and 289.4 cm2) from L3E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 5).

4.4 Length of leaf

Length of leaf showed significant differences for different bunch onion lines (Appendix VI). Longest leaf (13.5, 23.5, 30.5, 38.2, 44.6 and 47.6 cm) was recorded from L2 which was statistically similar or followed (12.2, 22.1, 29.5, 37.9, 43.4 and 45.3 cm) by L1, while the shortest leaf (9.62, 18.9, 26.9, 34.7, 40.8 and 43.3 cm) from L3 at 60, 80, 100, 120, 140 and 160 DAS (Table 6). Length of leaf varied for different lines/varieties might be due to genetical and environmental influences as well as management practices.

Table 4. Effect of different lines and earthing up on leaf area of Japanese bunch onion

Treatment	Leaf area (cm2) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
Japanese bunch onion lines						
L1	83.0 a	125.3 a	184.6 a	256.1 a	319.3 a	329.2 a
L2	84.9 a	128.7 a	187.7 a	260.1 a	324.0 a	333.0 a
L3	75.7 b	112.8 b	164.5 b	222.4 b	271.6 b	300.0 b
LSD(0.05)	4.256	4.541	10.34	11.86	21.12	21.23
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
Earthing up						
E0	72.4 b	115.1 b	170.2 b	226.8 b	270.5 b	297.4 b
E1	84.4 a	123.9 a	182.4 a	255.1 a	320.0 a	330.2 a
E2	86.9 a	127.8 a	184.2 a	256.8 a	324.4 a	334.7 a
LSD(0.05)	4.256	4.541	10.34	11.86	21.12	21.23
Level of significance	0.01	0.01	0.05	0.01	0.01	0.01
CV(%)	5.25	5.72	5.78	4.82	6.93	6.62

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

L1: White star
E0: Control (No earthing up)
L2: Moto kura
E1: Once earthing up
L3: Akahige or Red hero
E2: Twice earthing up

Table 5. Interaction effect of different lines and earthing up on leaf area of Japanese bunch onion

Treatment	Leaf area (cm2) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
L1E0	75.6 c	120.4 c	189.7 ab	246.1 bcd	296.3 c	306.4 b
L1E1	86.2 b	125.0 abc	174.3 b	255.3 abc	312.4 bc	329.2 ab
L1E2	87.1 ab	130.6 ab	189.7 ab	267.0 ab	349.2 ab	352.2 a
L2E0	72.8 c	122.9 bc	177.3 ab	234.3 cd	275.2 cd	296.3 b
L2E1	87.6 ab	129.9 ab	191.2 ab	271.0 a	344.1 ab	350.3 a
L2E2	94.4 a	133.2 a	194.6 a	275.1 a	352.9 a	352.5 a
L3E0	68.7 c	101.9 d	143.7 c	200.0 e	240.1 d	289.4 b
L3E1	72.5 c	116.7 c	178.3 ab	234.8 cd	294.7 c	311.2 b
L3E2	85.9 b	119.7 c	171.5 b	232.4 d	280.0 c	299.5 b
LSD(0.05)	7.372	7.866	17.90	20.54	36.59	36.77
Level of significance	0.01	0.05	0.01	0.05	0.05	

0.05

CV(%)	5.25	5.72	5.78	4.82	6.93	6.62

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

L1: White star
E0: Control (No earthing up)
L2: Moto kura
E1: Once earthing up
L3: Akahige or Red hero
E2: Twice earthing up

Table 6. Effect of different lines and earthing up on length of leaf of Japanese bunch onion

Treatment	Length of leaf (cm) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
Japanese bunch onion lines						
L1	12.2 a	22.1 b	29.5 a	37.9 a	43.4 ab	45.3 b
L2	13.5 a	23.5 a	30.5 a	38.2 a	44.6 a	47.6 a
L3	9.62 b	18.9 c	26.9 b	34.7 b	40.8 b	43.3 c
LSD(0.05)	1.468	1.355	2.103	2.309	2.800	1.626
Level of significance	0.01	0.01	0.01	0.01	0.05	0.01
Earthing up						
E0	10.1 b	18.9 b	26.9 b	34.4 b	41.0 b	42.6 b
E1	12.4 a	22.4 a	29.4 a	37.9 a	43.8 a	46.3 a
E2	12.9 a	23.0 a	30.6 a	38.4 a	44.0 a	47.2 a
LSD(0.05)	1.468	1.355	2.103	2.309	2.800	1.626
Level of significance	0.01	0.01	0.01	0.01	0.05	0.01
CV(%)	12.46	6.32	7.27	6.26	6.53	5.59

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

L1: White star
E0: Control (No earthing up)
L2: Moto kura
E1: Once earthing up
L3: Akahige or Red hero
E2: Twice earthing up

Different level of earthing up varied significantly on length of leaf (Appendix VI). Longest leaf (12.9, 23.0, 30.6, 38.4, 44.0 and 47.2 cm) was recorded from E2, which was statistically similar (12.4, 22.4, 29.4, 37.9, 43.8 and 46.3 cm) with E1, while the shortest leaf (10.1, 18.9, 26.9, 34.4, 41.0 and 42.6 cm) was found from E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 6).

Interaction effect of different bunch onion lines and earthing up showed significant variation for length of leaf (Appendix VI). Longest leaf (14.2, 25.6, 33.1, 41.8, 47.1 and 49.1 cm) was attained from L2E2, whereas the shortest leaf (8.45, 15.5, 23.5, 32.2, 38.6 and 40.4 cm) was observed from L3E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 7).

4.5 Weight of leaves per plant

Weight of leaves showed significant variation for different bunch onion lines (Appendix VII). Maximum weight of leaves per plant (15.5 g, 25.7 g, 44.1 g, 59.6 g, 77.2 g and 81.7 g) was recorded from L2 which was statistically similar (14.7 g, 24.9 g, 42.8 g, 58.9 g, 75.5 g and 78.3 g) with L1, while the minimum weight of leaves (12.9 g, 22.3 g, 39.2 g, 54.2 g, 72.0 g and 74.2 g) from L3 at 60, 80, 100, 120, 140 and 160 DAS (Table 8).

It was observed that different level of earthing up showed significant differences for weight of leaves per plant of Japanese bunch onion (Appendix VII). Maximum weight of leaves per plant (15.2 g, 25.9 g, 44.6 g, 60.1 g, 76.2 g and 80.5 g) was observed from E2, which was statistically identical (14.8 g, 25.4 g, 42.6 g, 59.1 g, 76.1 g and 79.7 g) with E1. On the other hand, the minimum weight of leaves (13.1 g, 21.6

g, 38.9 g, 53.5 g, 72.3 g and 74.0 g) was recorded from E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 8).

Table 7. Interaction effect of different lines and earthing up on length of leaf of Japanese bunch onion

Treatment	Length of leaf (cm) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
L1E0	8.90 c	17.7 e	26.3 cd	33.9 cd	39.4 cd	41.9 ef
L1E1	14.0 a	22.9 bc	29.0 bc	38.0 abc	44.5 abc	47.0 abc
L1E2	14.2 a	25.6 a	33.1 a	41.8 a	47.1 a	49.1 a
L2E0	12.9 ab	23.5 ab	30.8 ab	37.2 bc	45.0 ab	45.4 bcd
L2E1	13.6 a	24.3 ab	29.9 abc	38.1 abc	44.0 abc	48.2 ab
L2E2	14.2 a	22.5 bcd	30.9 ab	39.2 ab	44.6 abc	48.4 ab
L3E0	8.45 c	15.5 e	23.5 d	32.2 d	38.6 d	40.4 f
L3E1	9.59 c	20.1 d	29.4 abc	37.7 abc	42.9 abcd	43.8 de
L3E2	10.4 bc	21.0 cd	27.7 bc	34.3 cd	40.2 bcd	44.2 cde
LSD(0.05)	2.542	2.347	3.642	4.000	4.849	2.817
Level of significance	0.05	0.01	0.07	0.05	0.05	0.05
CV(%)	12.46	6.32	7.27	6.26	6.53	5.59

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

L1: White star
E0: Control (No earthing up)
L2: Moto kura
E1: Once earthing up
L3: Akahige or Red hero
E2: Twice earthing up

Table 8. Effect of different lines and earthing up on weight of leaves per plant of Japanese bunch onion

Treatment	Weight of leaves per plant (g) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
Japanese bunch onion lines						
L1	14.7 a	24.9 a	42.8 a	58.9 a	75.5 a	78.3 b
L2	15.5 a	25.7 a	44.1 a	59.6 a	77.2 a	81.7 a
L3	12.9 b	22.3 b	39.2 b	54.2 b	72.0 b	74.2 c
LSD(0.05)	0.899	1.275	3.466	4.185	2.879	2.750
Level of significance	0.01	0.01	0.05	0.05	0.01	0.01
Earthing up						
E0	13.1 b	21.6 b	38.9 b	53.5 b	72.3 b	74.0 b
E1	14.8 a	25.4 a	42.6 a	59.1 a	76.1 a	79.7 a
E2	15.2 a	25.9 a	44.6 a	60.1 a	76.2 a	80.5 a
LSD(0.05)	0.899	1.275	3.466	4.185	2.879	2.750
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV(%)	6.26	5.25	8.25	7.28	5.85	5.53

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

L1: White star
E0: Control (No earthing up)
L2: Moto kura
E1: Once earthing up
L3: Akahige or Red hero
E2: Twice earthing up

Interaction effect of different bunch onion lines and earthing up showed significant differences on weight of leaves per plant (Appendix VII). Maximum weight of leaves per plant (16.4 g, 28.2 g, 47.6 g, 64.8 g, 80.0 g and 83.8 g) was observed from L1E2, whereas the minimum weight of leaves (11.2 g, 18.8 g, 34.3 g, 50.7 g, 69.5 g and 71.4 g) was recorded from L3E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 9).

4.6 Length of pseudostem

Different bunch onion lines showed significant differences for length of pseudostem (Appendix VIII). Longest pseudostem (4.38, 6.60, 9.36, 11.3, 12.9 and 13.2 cm) was observed from L2 which was similar (4.29, 6.38, 9.10, 11.0, 12.7 and 13.0 cm) with L1, again the shortest pseudostem (3.87, 5.62, 8.03, 9.94 , 11.5 and 11.8 cm) from L3 at 60, 80, 100, 120, 140 and 160 DAS (Figure 4). Different lines/varieties responded differently to input supply, method of cultivation and the prevailing environment during the growing season. Eugeniusz et al. (2012) reported highest length of pseudostem 14.1 cm which are similar to the findings of this experiment.

Significant variation was observed for different level of earthing up in terms of length of pseudostem of Japanese bunch onion (Appendix VIII). Longest pseudostem (4.48, 6.56, 9.33, 11.2, 12.9 and 13.2 cm) was recorded from E2, which was statistically identical (4.37, 6.45, 9.14, 11.0, 12.7 and 13.2 cm) with E1, whereas the shortest pseudostem (3.69, 5.58, 8.01, 9.99, 11.4 and 11.7 cm) was recorded from E0 at 60, 80, 100, 120, 140 and 160 DAS (Figure 5).

Bunch onion lines and earthing up showed significant differences on length of pseudostem due to the interaction effect (Appendix VIII). Longest pseudostem (4.82, 7.04, 9.92, 11.7, 13.6 and 13.9 cm) was observed from L2E2, again the shortest pseudostem (3.36, 4.90, 6.82, 9.52, 10.4 and 10.6 cm) from L3E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 10).

Table 9. Interaction effect of different lines and earthing up on weight of leaves per plant of Japanese bunch onion

Treatment	Weight of leaves per plant (g) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
L1E0	12.5 cd	20.9 d	38.7 cd	52.8 bc	70.0 bc	72.0 d
L1E1	15.0 ab	25.7 bc	42.3 abc	59.1 ab	77.0 a	80.4 ab
L1E2	16.4 a	28.2 a	47.6 a	64.8 a	80.0 a	83.8 a
L2E0	15.7 ab	25.0 bc	43.9 abc	57.1 abc	77.4 a	78.6 abc
L2E1	15.8 a	27.2 ab	42.8 abc	59.5 ab	76.6 a	82.6 a
L2E2	15.1 ab	25.0 bc	45.7 ab	62.1 a	77.6 a	83.2 a
L3E0	11.2 d	18.8 d	34.3 d	50.7 c	69.5 c	71.4 d
L3E1	13.4 c	23.5 c	42.9 abc	58.6 abc	74.9 ab	76.1 bcd
L3E2	14.1 bc	24.6 c	40.4 bcd	53.4 bc	71.0 bc	74.6 cd
LSD(0.05)	1.558	2.209	6.003	7.249	4.987	4.763
Level of significance	0.01	0.01	0.05	0.05	0.05	0.05
CV(%)	6.26	5.25	8.25	7.28	5.85	5.53

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

L1: White star	E0: Control (No earthing up)
L2: Moto kura	E1: Once earthing up
L3: Akahige or Red hero	E2: Twice earthing up

Table 10. Interaction effect of different lines and earthing up on length of pseudostem of Japanese bunch onion

Treatment	Length of pseudostem (cm) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
L1E0	3.91 b	5.64 e	8.35 d	9.79 c	12.2 bc	12.7 abc
L1E1	4.44 a	6.47 bcd	9.02 bcd	11.3 ab	12.5 abc	12.9 abc
L1E2	4.51 a	6.68 abc	9.75 ab	11.7 a	13.3 ab	13.4 ab
L2E0	3.80 b	6.22 cd	8.87 cd	10.7 abc		

					11.7 c	11.8 c
L2E1	4.52 a	6.89 ab	9.45 abc	11.5 a	13.4 ab	13.7 a
L2E2	4.82 a	7.04 a	9.92 a	11.7 a	13.6 a	13.9 a
L3E0	3.36 c	4.90 f	6.82 e	9.5 c	10.4 d	10.6 d
L3E1	3.85 b	5.98 de	8.95 bcd	10.1 bc	12.3 abc	12.6 abc
L3E2	4.40 a	5.97 de	8.33 d	10.2 bc	11.8 c	12.3 bc
LSD(0.05)	0.410	0.499	0.760	1.178	1.260	1.174
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
CV(%)	5.65	4.65	4.97	6.34	5.89	5.36

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

L1: White star E0: Control (No earthing up) L2: Moto kura E1: Once earthing up L3: Akahige or Red hero E2: Twice earthing up

4.7 Diameter of pseudostem

It was revealed that diameter of pseudostem varied significantly for different bunch onion lines (Appendix IX). Highest diameter of pseudostem (8.17, 11.5, 16.9, 19.1, 20.3 and 20.8 mm) was observed from L2 which was statistically identical (7.90, 11.2, 16.6, 18.9, 19.8 and 20.6 mm) with L1, whereas the lowest diameter of pseudostem (7.55, 10.7, 14.6, 16.9, 18.3 and 18.6 mm) was recorded from L3 at 60, 80, 100, 120, 140 and 160 DAS (Figure 6). Management practices influence the diameter of pseudostem but variety itself also manipulated it. Eugeniusz et al. (2012) reported highest pseudostem diameter 17.3 mm which are similar to the findings of this experiment.

Diameter of pseudostem of Japanese bunch onion varied significantly for different level of earthing up (Appendix IX). Highest diameter of pseudostem (8.37, 11.7, 17.1, 19.2, 20.2 and 20.5 mm) was found from E2, which was statistically identical (7.95, 11.2, 17.0, 19.0, 19.7 and 20.4 mm) with E1, again the lowest diameter of pseudostem (7.29, 10.5, 14.0, 16.8, 18.5 and 19.1 mm) was observed from E0 at 60, 80, 100, 120, 140 and 160 DAS (Figure 7). Earthing up of soil to the base of the Negi plant may increase diameter of the underground portion of the plant which is an indication of better quality and higher yield. Kumar and Gowda (2010) reported that yield, the crop responded significantly due to earthing up.

Significant variation was recorded for the interaction effect of different bunch onion lines and earthing up for diameter of pseudostem (Appendix IX). Highest diameter of pseudostem (8.82, 12.3, 18.3, 20.1, 20.8 and 21.4 mm) was observed from L2E2, while the lowest diameter (7.27, 10.4, 13.0, 15.6, 16.9 and 17.1 mm) was found from L3E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 11).

Table 11. Interaction effect of different lines and earthing up on diameter of pseudostem of Japanese bunch onion

Treatment	Diameter of pseudostem (mm) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
L1E0	7.28 c	10.4 b	14.7 b	17.5 d	19.0 c	20.4 b
L1E1	7.78 bc	10.9 b	17.0 a	18.9 bc	19.8 bc	20.4 b
L1E2	8.64 a	12.1 a	18.0 a	20.3 a	20.8 a	21.1 a
L2E0	7.33 c	10.6 b	14.3 b	17.2 d	19.6 bc	19.7 c
L2E1	8.36 ab	11.6 ab	18.1 a	20.0 ab	20.4 ab	21.2 a
L2E2	8.82 a	12.3 a	18.3 a	20.1 a	20.8 a	21.4 a
L3E0	7.27 c	10.4 b	13.0 c	15.6 e	16.9 d	17.1 e
L3E1	7.72 bc	11.1 b	15.6 b	18.0 cd	19.0 c	19.7 c
L3E2	7.65 bc	10.5 b	15.2 b			

17.2 d   19.0 c   18.9 dLSD(0.05)   0.760   1.030   1.272   1.103
0.799   0.545Level of significance   0.05   0.05   0.05   0.05
0.05   0.01CV(%)   5.58   5.36   4.59   5.48   5.37   4.57In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

L1: White starE0: Control (No earthing up)L2: Moto kuraE1: Once earthing upL3: Akahige or Red heroE2: Twice earthing up

4.8   Weight of pseudostem

Weight of pseudostem varied significantly for different bunch onion lines (Appendix X) under the present trial. Maximum weight of pseudostem (4.27 g, 8.18 g, 12.7 g, 20.5 g, 26.9 g and 28.5 g) was observed from L2 which was statistically similar (4.25 g, 8.01 g, 12.3 g, 19.7 g, 26.4 g and 28.2 g) with L1, while the minimum weight of pseudostem (3.95 g, 7.21 g, 11.3 g, 17.3 g, 23.4 g and 24.7 g) from L3 at 60, 80, 100, 120, 140 and 160 DAS (Table 12). Different lines/varieties responded differently to input supply, method of cultivation and the prevailing environment during the growing season although it was also governed by genetically.

Significant variation was recorded for different level of earthing up in terms of weight of pseudostem of Japanese bunch onion (Appendix X). Maximum weight of pseudostem (4.38 g, 8.19 g, 12.7 g, 20.2 g, 26.7 g and 28.8 g) was found from E2, which was statistically identical (4.31 g, 8.08 g, 12.3 g, 19.8 g, 26.6 g and 28.2 g) with E1, whereas the minimum weight of pseudostem (3.78 g, 7.13 g, 11.3 g, 17.5 g, 23.5 g and 24.5 g) was attained from E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 12).

Different bunch onion lines and earthing up showed significant differences on weight of pseudostem due to interaction effect (Appendix X). Maximum weight of pseudostem (4.63 g, 8.54 g, 13.2 g, 21.4 g, 28.4 g and 30.5 g) was recorded from L2E2, again the minimum weight of pseudostem (3.60 g, 6.47 g, 10.6 g, 16.3 g, 20.4 g and 20.9 g) was found from L3E0 at 60, 80, 100, 120, 140 and 160 DAS (Table 13).

4.9   Yield per plot

Yield per plot showed significant variation for different bunch onion lines (Appendix X). The highest yield per plot (2.85 kg) was found from L2 which was statistically similar (2.82 kg) with L1, whereas the lowest yield per plot (2.47 kg) from L3 (Figure 8).

Table 12.   Effect of different lines and earthing up on weight of pseudostem of Japanese bunch onion

TreatmentWeight of pseudostem (g) at   60 DAS   80 DAS   100 DAS
120 DAS   140 DAS   160 DASJapanese bunch onion linesL1   4.25 a
8.01 a   12.3 a   19.7 a   26.4 a   28.2 aL2   4.27 a   8.18 a
12.7 a   20.5 a   26.9 a   28.5 aL3   3.95 b   7.21 b   11.3 b
17.3 b   23.4 b   24.7 bLSD(0.05)   0.184   0.324   0.497   1.578
1.552   1.434Level of significance   0.01   0.01   0.01   0.01
0.01   0.01Earthing upE0   3.78 b   7.13 b   11.3 b   17.5 b   23.5
b   24.5 bE1   4.31 a   8.08 a   12.3 a   19.8 a   26.6 a   28.2
aE2   4.38 a   8.19 a   12.7 a   20.2 a   26.7 a   28.8 aLSD(0.05)
0.184   0.324   0.497   1.578   1.552   1.434Level of significance
0.01   0.01   0.01   0.01   0.01   0.01CV(%)   4.41   6.16   4.12
8.24   6.07   5.28In a column means having similar letter(s) are

statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

L1: White star
E0: Control (No earthing up)
L2: Moto kura
E1: Once earthing up
L3: Akahige or Red hero
E2: Twice earthing up

Table 13. Interaction effect of different lines and earthing up on weight of pseudostem of Japanese bunch onion

Treatment	Weight of pseudostem (g) at					
	60 DAS	80 DAS	100 DAS	120 DAS	140 DAS	160 DAS
L1E0	3.96 b	7.23 c	11.2 cd	17.3 c	25.5 ab	27.2 bc
L1E1	4.38 a	8.10 ab	12.1 bc	20.5 ab	26.1 ab	27.8 bc
L1E2	4.40 a	8.69 a	13.4 a	21.4 a	27.6 a	29.5 ab
L2E0	3.78 bc	7.68 bc	12.0 bc	19.0 abc	24.5 b	25.4 c
L2E1	4.40 a	8.31 a	12.8 ab	21.0 a	28.0 a	29.7 ab
L2E2	4.63 a	8.54 a	13.2 a	21.4 a	28.4 a	30.5 a
L3E0	3.60 c	6.47 d	10.6 d	16.3 c	20.4 c	20.9 d
L3E1	3.92 bc	7.59 bc	12.0 bc	17.9 bc	25.7 ab	27.1 bc
L3E2	4.33 a	7.58 bc	11.4 cd	17.7 bc	24.1 b	26.3 c
LSD(0.05)	0.319	0.561	0.860	2.733	2.688	2.483
Level of significance	0.05	0.05	0.05	0.05	0.05	0.05
CV(%)	4.41	6.16	4.12	8.24	6.07	5.28

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

L1: White star
E0: Control (No earthing up)
L2: Moto kura
E1: Once earthing up
L3: Akahige or Red hero
E2: Twice earthing up

Different level of earthing up showed significant variation on yield per plot of Japanese bunch onion (Appendix X). The highest yield per plot (2.88 kg) was recorded from E2, which was statistically identical (2.82 kg) with E1, again the lowest yield per plot (2.45 kg) was recorded from E0 (Figure 9).

It was revealed that interaction effect of different bunch onion lines and earthing up showed significant differences on yield per plot (Appendix X). The highest yield per plot (3.05 kg) was observed from L2E2, while the lowest yield per plot (2.09 kg) was observed from L3E0 (Figure 10).

4.10 Yield per hectare

Significant variation was recorded in terms of yield per due to different bunch onion lines (Appendix X). The highest yield per hectare (14.3 ton) was observed from L2 which was statistically similar (14.1 ton) with L1, while the lowest yield per hectare (12.4 ton) from L3 (Figure 11). Different line of Negi have different yield potentiality and these lines respond differently to input supply, cultivation practices and the prevailing environment during the growing season. Kretschmer (2002) reported that varieties ‘BGS180’, ‘Hytech’, ‘BGS162’, and ‘BGS173’. For ‘BGS180’ a high yield. Eugeniusz et al. (2012) reported highest marketable yield 16.14 ton from earlier experiment.

Yield per hectare of Japanese bunch onion showed significant variation for different level of earthing up (Appendix X). The highest yield per hectare (14.4) was found from E2, which was statistically identical (14.1) with E1. On the other hand the lowest yield per hectare (12.3) was recorded from E0 (Figure 12).

Interaction effect of different bunch onion lines and earthing up showed significant differences on yield per hectare (Appendix X). The highest yield per hectare (15.3 ton) was observed from L2E2, whereas the lowest yield per hectare (10.4 ton) was found from L3E0 (Figure 13).

CHAPTER V

SUMMARY AND CONCLUSION

The study was conducted in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from December 2011 to May 2012 to find out the influence of earthing up on growth and yield of Japanese bunch onion lines. Japanese bunch onion lines were used as the test crop of this experiment. The experiment consisted of two factors: Factor A: Japanese bunch onion lines (three lines) as L1: White star, L2: Moto kura and L3: Akahige or Red hero; and Factor B: Earthing up (three levels) as E0: No earthing up (control), E1: Once earthing up and E2: Twice earthing up. There were 9 (3 × 3) treatments combination. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on different yield attributing characters and yield was recorded and significant variation was observed for all the characters that recorded parameters.

For different bunch onion lines, at 60, 80, 100, 120, 140 and 160 DAS respectively, the tallest plant (17.9, 30.0, 39.9, 49.5, 57.5 and 60.7 cm) was recorded from L2, whereas the shortest plant (13.5, 24.5, 34.9, 44.6, 52.3 and 55.1 cm) from L3. The maximum number of leaves per plant (3.36, 4.82, 5.91, 7.22, 8.16 and 8.33) was found from L2, while the minimum number (2.89, 4.22, 5.13, 6.27, 6.98 and 7.16) from L3. The highest leaf area (84.9, 128.7, 187.7, 260.1, 324.0 and 333.0 cm2) was observed from L2 again the lowest leaf area (75.7, 112.8, 164.5, 222.4, 271.6 and 300.0 cm2) from L3. The longest leaf (13.5, 23.5, 30.5, 38.2, 44.6 and 47.6 cm) was recorded from L2, while the shortest leaf (9.62, 18.9, 26.9, 34.7, 40.8 and 43.3 cm) from L3. The maximum weight of leaves per plant (15.5, 25.7, 44.1, 59.6, 77.2 and 81.7 g) was recorded from L2, while the minimum weight of leaves (12.9, 22.3, 39.2, 54.2, 72.0 and 74.2 g) from L3. The longest pseudostem (4.38, 6.60, 9.36, 11.3, 12.9 and 13.2 cm) was observed from L2, again the shortest pseudostem (3.87, 5.62, 8.03, 9.94, 11.5 and 11.8 cm) from L3. The highest diameter of pseudostem (8.17, 11.5, 16.9, 19.1, 20.3 and 20.8 mm) was observed from L2, whereas the lowest diameter of pseudostem (.55, 10.7, 14.6, 16.9, 18.3 and 18.6 mm) was recorded from L3. The maximum weight of pseudostem (4.27, 8.18, 12.7, 20.5, 26.9 and 28.5 g) was observed from L2, while the minimum weight of pseudostem (3.95, 7.21, 11.3, 17.3, 23.4 and 24.7 g) from L3 at mentioned days after sowing. The highest yield per plot (2.85 kg) and yield per hectare (14.3 ton) was found from L2, whereas the lowest yield per plot (2.47 kg) and yield per hectare (12.4 ton) from L3.

For earthing up at 60, 80, 100, 120, 140 and 160 DAS respectively, the tallest plant (17.4, 29.6, 39.9, 49.6, 56.9 and 60.4 cm) was observed from E2, again the shortest plant (13.8, 24.5, 34.9, 44.4, 52.4 and 54.3 cm) was recorded from E0. The maximum number of leaves per plant (3.36, 4.80, 5.87, 7.04, 8.20 and 8.44) was recorded from E2 and the minimum number (2.84, 4.31, 5.18, 6.49, 6.80 and 6.96) was found from E0. The

highest leaf area (86.9, 127.8, 184.2, 256.8, 324.4 and 334.7 cm2) was found from E2, whereas the lowest leaf area (72.4, 115.1, 170.2, 226.8, 270.5 and 297.4 cm2) was observed from E0. The longest leaf (12.9, 23.0, 30.6, 38.4, 44.0 and 47.2 cm) was recorded from E2, while the shortest leaf (10.1, 18.9, 26.9, 34.4, 41.0 and 42.6 cm) was found from E0. The maximum weight of leaves per plant (15.2, 25.9, 44.6, 60.1, 76.2 and 80.5 g) was observed from E2 and the minimum weight of leaves (13.1, 21.6, 38.9, 53.5, 72.3 and 74.0 g) was recorded from E0. The longest pseudostem (4.48, 6.56, 9.33, 11.2, 12.9 and 13.2 cm) was recorded from E2, whereas the shortest pseudostem (.69, 5.58, 8.01, 9.99, 11.4 and 11.7 cm) was recorded from E0. The highest diameter of pseudostem (8.37, 11.7, 17.1, 19.2, 20.2 and 20.5 mm) was found from E2, again the lowest diameter of pseudostem (7.29, 10.5, 14.0, 16.8, 18.5 and 19.1 mm) was observed from E0. The maximum weight of pseudostem (4.38 g, 8.19 g, 12.7 g, 20.2 g, 26.7 g and 28.8 g) was found from E2, whereas the minimum weight of pseudostem (3.78, 7.13, 11.3, 17.5, 23.5 and 24.5 g) was attained from E0 at same DAS. The highest yield per plot (2.88 kg) and yield per hectare (14.4 ton) was recorded from E2, again the lowest yield per plot (2.45 kg) and yield per hectare (12.3 ton) was recorded from E0.
In case of interaction effect of bunch onion lines and earthing up at 60, 80, 100, 120, 140 and 160 DAS respectively the tallest plant (18.7, 32.6, 43.0, 53.5, 60.4 and 62.9 cm) was observed from L2E2, while the shortest (12.3, 20.4, 30.3, 41.7, 49.7 and 52.5 cm) was recorded from L3E0. The maximum number of leaves per plant (3.60, 5.47, 6.40, 7.60, 9.00 and 9.40) was attained from L2E2 and the minimum number (2.60, 3.93, 5.07, 5.87, 6.07 and 6.13) was recorded from L3E0. The highest leaf area (94.4, 133.2, 194.6, 275.1, 352.9 and 352.5 cm2) was recorded from L2E2, again the lowest leaf area (68.7, 101.9, 143.7, 200.0, 240.1 and 289.4 cm2) was recorded from L3E0. The longest leaf (14.2, 25.6, 33.1, 41.8, 47.1 and 49.1 cm) was attained from L2E2, whereas the shortest leaf (8.45, 15.5, 23.5, 32.2, 38.6 and 40.4 cm) was observed from L3E0. The maximum weight of leaves per plant (16.4, 28.2, 47.6, 64.8, 80.0 and 83.8 g) was observed from L1E2, whereas the minimum weight of leaves (11.2, 18.8, 34.3, 50.7, 69.5 and 71.4 g) was recorded from L3E0. The longest pseudostem (4.82, 7.04, 9.92, 11.7, 13.6 and 13.9 cm) was observed from L2E2, again the shortest pseudostem (3.36, 4.90, 6.82, 9.52, 10.4 and 10.6 cm) was found from L3E0. The highest diameter of pseudostem (8.82, 12.3, 18.3, 20.1, 20.8 and 21.4 mm) was observed from L2E2, while the lowest diameter of pseudostem (7.27, 10.4, 13.0, 15.6, 16.9 and 17.1 mm) was found from L3E0. The maximum weight of pseudostem (4.63, 8.54, 13.2, 21.4, 28.4 and 30.5 g) was recorded from L2E2, again the minimum weight of pseudostem (33.60, 6.47, 10.6, 16.3, 20.4 and 20.9 g) was found from L3E0. The highest yield per plot (3.05 kg) and yield per hectare (15.3 ton) was observed from L2E2, while the lowest yield per plot (2.09 kg) and yield per hectare (10.4 ton) was observed from L3E0.

Considering the findings of the present experiment, it may be concluded that:
1. Moto kura line showed significantly better performance compared to the other lines that used in this experiment.
2. Twice earthing up was better in terms of all yield contributing attributes and yield of bunch onion.

3. The treatment combination of L2E2 (Moto kura and twice earthing up) also showed best potentiality in consideration of yield contributing attributes and yield of Japanese bunch onion.
4. So, this treatment combination seemed promising for cultivation in Bangladesh.

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APPENDICES

Appendix I. Monthly record of air temperature, relative humidity, rainfall, and sunshine of the experimental site during the period from December 2011 to May 2012

Month*Air temperature (ºc)*Relative humidity (%)*Rainfall (mm)*Sunshine (hr)MaximumMinimumDecember, 201122.413.574006.3January, 201224.512.4 68005.7February, 201227.116.7 67306.7March, 201231.419.654118.2April, 201234.223.4611128.1May, 201234.725.9701857.8* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargaon, Dhaka – 1212

Appendix II. Physical characteristics of field soil analyzed in Soil Resources Development Institute (SRDI) laboratory, Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological featuresCharacteristicsLocationAgronomy field, SAU, DhakaAEZMadhupur Tract (28)General Soil TypeShallow red brown terrace soilLand typeHigh landSoil seriesTejgaonTopographyFairly leveledFlood levelAbove flood levelDrainageWell drainedB. Physical and chemical properties of the initial soil

CharacteristicsValue % Sand 27% Silt 43% clay 30Textural class Silty-claypH5.6Organic carbon (%)0.45Organic matter (%)0.78Total N (%)0.03Available P (ppm)20.00Exchangeable K (me/100 g soil)0.10Available S (ppm)45 Source: Soil Resources Development Institute (SRDI)

Appendix III. Analysis of variance of the data on plant height at different days after sowing (DAS) of Japanese bunch onion as influenced by different lines and erthing up

Source of variationDegrees of freedomMean squarePlant height (cm) at 60 DAS 80 DAS 100 DAS 120 DAS 140 DAS 160 DASReplication2 0.016 0.423 0.280 0.111 0.897 1.461Bunch onion line (A)2 45.997** 74.067** 60.312** 61.620** 63.880** 71.748**Earthing up (B)2 33.918** 68.375** 60.686** 72.591** 56.155** 97.771**Interaction (A×B)4 6.531* 19.761** 22.358* 18.168* 20.194* 4.385*Error16 1.913 2.348 6.196 5.099 6.086 2.346**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of leaves per plant at different days after sowing (DAS) of Japanese bunch onion as influenced by different lines and erthing up

Source of variationDegrees of freedomMean squareNumber of leaves per plant at 60 DAS 80 DAS 100 DAS 120 DAS 140 DAS 160 DASReplication2 0.018 0.018 0.013 0.031 0.120 0.093Bunch onion line (A)2 0.520** 0.973** 1.391** 2.324** 3.524** 3.684**Earthing up (B)2 0.671** 0.591** 1.098** 0.858** 5.373** 5.951**Interaction (A×B)4 0.238* 0.964** 0.276** 0.136* 0.731** 1.089**Error16 0.041 0.046 0.055 0.046 0.132 0.158**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on leaf area at different days after sowing (DAS) of Japanese bunch onion as influenced by different lines and erthing up

Source of variationDegrees of freedomMean squareLeaf area (cm2) at 60 DAS 80 DAS 100 DAS 120 DAS 140 DAS 160 DASReplication2 9.297 8.855 57.694 93.319 346.283 496.817Bunch onion line (A)2 213.925** 633.405** 1428.227** 3859.369** 7567.484** 2934.778**Earthing up (B)2 541.597** 384.011** 518.244* 2550.208** 8050.398** 3742.763**Interaction (A×B)4 97.401** 64.428* 491.687** 212.318* 988.900* 613.673*Error16 18.138 20.651 106.990 140.772 446.815 451.297**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on length of leaf at different days after sowing (DAS) of Japanese bunch onion as influenced by different lines and erthing up

Source of variationDegrees of freedomMean squareLength of leaf (cm) at 60 DAS 80 DAS 100 DAS 120 DAS 140 DAS 160 DASReplication2 0.005 0.429 0.080 0.539 1.011 2.388Bunch onion line (A)2 35.733** 49.934** 32.120** 33.110** 33.220* 41.927**Earthing up (B)2 20.640** 44.428** 32.194** 43.360** 25.584* 54.275**Interaction (A×B)4 7.037* 16.128** 15.586* 15.234* 21.652* 7.662*Error16 2.157 1.838 4.427 5.340 7.849 2.648**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data on weight of leaves per plant at different days after sowing (DAS) of Japanese bunch onion as influenced by different lines and erthing up

Source of variationDegrees of freedomMean squareWeight of leaves per plant (g) at 60 DAS 80 DAS 100 DAS 120 DAS 140 DAS 160 DASReplication2 0.157 0.437 0.583 2.311 3.522 7.803Bunch onion line (A)2 16.293** 29.304** 59.042* 75.995* 64.511** 125.150**Earthing up (B)2 10.637** 50.977** 74.127** 111.251** 45.517** 114.546**Interaction (A×B)4 3.974** 11.596** 26.446* 31.674* 31.997* 17.466*Error16 0.810 1.629 12.029 17.539 8.301 7.572**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data on length of pseudostem at different days after sowing (DAS) of Japanese bunch onion as influenced by different lines and erthing up

Source of variationDegrees of freedomMean squareLength of pseudostem (cm) at 60 DAS 80 DAS 100 DAS 120 DAS 140 DAS 160 DASReplication2 0.003 0.078 0.061 0.662 0.055 0.115Bunch onion line (A)2 0.665** 2.387** 4.436** 4.506** 5.033** 4.691**Earthing up (B)2 1.643** 2.573** 4.570** 3.751** 5.941** 6.508**Interaction (A×B)4 0.159* 0.219* 0.748* 0.937* 0.937* 0.898*Error16 0.056 0.083 0.193 0.463 0.530 0.460**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data on diameter of pseudostem at different days after sowing (DAS) of Japanese bunch onion as influenced by different lines and erthing up

Source of variationDegrees of freedomMean squareDiameter of pseudostem (mm) at 60 DAS 80 DAS 100 DAS 120 DAS 140 DAS 160 DASReplication2 0.147 0.010 0.130 0.603 0.083 0.037Bunch onion line (A)2 0.877* 1.512* 13.915** 13.106** 9.500** 13.622**Earthing up (B)2 2.658** 3.063** 28.164** 16.081** 6.548** 5.742**Interaction (A×B)4 0.342* 0.970* 1.020* 1.021* 0.505* 1.320**Error16 0.193 0.354 0.540 0.406 0.213 0.099**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix X. Analysis of variance of the data on weight of pseudostem, yield per plot and yield per hectare at different days after sowing (DAS) of Japanese bunch onion as influenced by different lines and erthing up

Source of variationDegrees of freedomMean squareWeight of pseudostem (g) atYield (kg/plot)Yield (t/ha)60 DAS80 DAS100 DAS120 DAS140 DAS160 DAS Replication20.0220.1420.0364.0990.1731.3580.0140.339Bunch onion line (A)20.285**2.378**4.302**24.829**32.394**39.735**0.397**9.934**Earthing up (B)20.959**3.059**4.927**18.884**30.881**47.914**0.479**11.979**Interaction (A×B)40.106*0.186*0.786*4.421*4.499*6.330*0.063*1.583*Error160.0340.1050.2472.4932.4122.0580.0210.514**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability