International Journal of Advanced Research and Review

www.ijarr.in

EFFECT OF SPACING AND LEVELS OF NITROGEN ON GROWTH AND BULB YIELD OF RED ONION (*ALLIUM CEPA* VAR. *ASCALONICUM*)

Harris, K. D.[1*] Suthaharan, S.[2] and Geretharan, T.[3]

[1,2,3] Department of Crop Science, Faculty of Agriculture, Eastern University, Chenkalady, Sri Lanka. [*]kumuthiniharris@yahoo.com

ABSTRACT

A field experiment was conducted at the Crop Farm of Eastern University, Sri Lanka to investigate the effect of plant spacing and levels of nitrogen on yield of onion (cv. Vethalan) in the sandy regosols in the Batticaloa District. Three plant spacing viz; 8 cm x 8 cm, 10 cm x 10 cm and 10 cm x 12 cm and three levels of nitrogen namely 120, 150 and180 kg N/ha were used. This experiment was carried out using a 3 x 2 Factorial Randomized Complete Block Design (RCBD) replicated three times. All other agronomic practices were done as recommended by the Department of Agriculture. The data on height, bulb diameter, fresh weight and number of bulbs were recorded. Significant variations were recorded for spacing and levels of nitrogen for all the parameters studied. Highest bulb yield was obtained at the spacing of 8 x 8 cm in combination with 150 kg N/ha and 150 kg N/ha was found to be the optimum nitrogen for all three spacing tested. Therefore, it is concluded that profitable yield could be obtained at a spacing of 8 x 8 cm in combination with 150 kg N/ ha.

Key words: Nitrogen, bulbs, optimum, spacing

INTRODUCTION

Onion (*Allium cepa* L.) belongs to the genus Allium and the family Alliaceae. It is one of the most important bulb, vegetable, cash, and spice and condiment crops cultivated all over the world on commercial scale both for local consumption and export. Onions provide flavour as well as essential nutrients and health-promoting phytochemicals (Craig, 1999). Onions are a good source of dietary fiber, helps to lower the blood sugar level in diabetics, and folic acid. They also contain minerals like calcium, iron, and have a high protein (Onion Health Research, 2013).

China is the largest producer of onion with the production of 10.03 million tons from 0.45 million ha while India ranked the second, producing from 4.3 million tons from 0.405 million/ ha (FAOSTAT, 2012). In Sri Lanka, total production of onion is 46,034 Mt in an extent of 9,661 ha (Department of Agriculture, 2012). In the Batticaloa District, onion is grown in an extent of about 74 ha with a total production of 148,81Mt (Agricultural Implementation Programme, 2013).

Optimum plant density is a pre-requisite for maximum yield. Increasing plant density results in suppression of biological yield of individual plant, but production increases on per plant basis of unit land area. Plant density greatly influenced quality, texture, taste and yield of onion (Dawar *et al*., 2007). Khan *et al.* (2002) reported a significant effect of all the growth and yield components of onion and larger percentage of small and medium bulbs were obtained in the narrowest spacing. Coleo *et al*. (1996) reported that highest commercial bulb yield was recorded at higher planting density (closest spacing); while the highest proportion of large bulbs and average bulb weight were obtained at the lowest planting density (wider spacing).

The amount of nitrogen for onion production may vary with soil type, the previous crop, amount of organic matter present in the soil and the environmental conditions that prevail during the crop growing season.

Nitrogen is essential for growth and yield of onion but application of high rates cause delay in bulb maturity and encourage bolting (flowering), which is an undesirable characteristics (Aliyu *et al*., 2007). Nitrogen has great impact on flavor, quality and development of bulb in onions (Randle, 2000), but significantly affect crop-weed competitive interactions (Raun and Johnson, 1999). Much attention should be given to fertilizer management of onion plant when compared to other crops, since onion possesses shallow root system and faces problem in the absorption of immobile nutrients in the soil (Brewster, 1994) maximum yield (Halvorson *et al*., 2008).

To date, no systematic study has been carried out in order to test the effect of plant spacing on yield and no evidence is available on the response of nitrogen in regosols. Hence, this investigation was undertaken to study the effect of spacing and levels of nitrogen on growth and bulb yield of red onion (cv. Vethalan) in the regosols in the Batticaloa District.

MATERIALS AND METHODS

The investigation was carried out at the Crop Farm, Eastern University, Chenkalady during the period from May to July 2013 on a sandy soil to study the effect of spacing and levels of nitrogen on growth and bulb yield of red onion (cv. vethalan) (Latitude between 7^0 43' and 7^0 431/2' N and the Longitude between 81^0 42' and 81^0 43' E), which falls within dry zone of Sri Lanka and DL2 agro-ecological zone (De Alwis and Panabokke, 1972). The texture of the soil was sandy with structure less single grain.

The experiment was carried out using a 3 x 2 Factorial Randomized Complete Block Design (RCBD) replicated three times. The spacing was tested in combination with different levels of nitrogen. The spacing's viz. 8 x 8 cm, 10 x 10 cm and 10 x 12 cm were tested with 3 levels of nitrogen (180, 150 and 120 kg /ha). Therefore, there were 27 treatment combinations.

All other agronomic practices were done as recommended by the Department of Agriculture and nitrogen was applied at the rate of 120, 150, and 180 kg N /ha, and P_2O_5 and K_2O were applied at the rate of 100 and 85 kg/ha respectively (Department of Agriculture, 1990). Basal application of 50 kg N/ha was similar to all treatments. Rest of the nitrogen was split into two halves and given in two top dressings at 3rd and 6th weeks after planting (WAP). Weeds were removed prior to top dressing.

Sampling was done at every fortnight on six occasions starting from 1 month after planting (MAP). Five plants were harvested randomly uprooted for assessment at each occasion from each plot for growth measurements and bulb yield was obtained from an area of 1 sq. m at harvest. Dry weights were determined by drying the samples in oven at 80^0C for a period of 48 hours. The data were analyzed and the means were compared by using LSD at 5% level.

RESULTS AND DISCUSSION

Height

Plant spacing

The result presented in Table. 1 indicated that the plant height of onion was significantly affected by spacing at different stages of growth. The plant height was significantly increased up to 75 DAP and then decreased (Table 1). However, the plant density did not affect the height at 30 days after planting (DAP).

At 90 DAP, plant height significantly increased (P< 0.05) with decrease in plant spacing. The highest plant height was recorded at the spacing of 8 × 8 cm and shortest plant height was in 10 × 10 cm (Table. 1). This may be due to, as the spacing between the plants becomes closer; the plants tend to grow taller in order to access more sunlight and the reduction of plant height at harvest was absolutely due to the shrinkage of leaves.

Levels of nitrogen

Levels of nitrogen did not affect the plant height at 30 and 90 DAP (Table. 1). This may be probably due to low nutrient utilization by the seedlings at early stages of crop growth and leaching of applied nitrogen during later stages of crop growth.

Interaction

Interaction was observed between plant spacing and levels of nitrogen at 60 (P<0.0001) and 75 DAP (P<0.0001) (Table. 1). At 60 DAP, highest plant height (21.7 cm) was obtained in closest plant spacing 8 x 8 cm with 150 kg N/ha and shortest height was observed in the spacing of 8 x 8 cm with 120 kg N/ha, 10 x 10 cm with 120 kg N/ha, 10 x 12 cm with 180 and 150 kg N/ha (Table. 1). At 60 DAP, as the rate nitrogen increased from 120 to 150 kg N/ha plant height also increased at the closest spacing and further increase in the rate nitrogen decreased the height. However, there were no differences in the rate of nitrogen within spacing 10 x 10 cm and 10 x 12 cm. At 75 DAP, increase the level of nitrogen from 120 to 150 kg N/ha increased the plant height and further increase had no effect on the plant height. It is also evident that highest level of nitrogen was effectively utilized by the highest density (closest spacing- 8 x 8 cm) and vice versa.

Therefore, increase in nitrogen from 120 to 150 kg N/ha, increased the plant height. This was due to nitrogen. Nitrogen is one of the major plant nutrients that cause vegetative growth in plants. Application of adequate nitrogen leads to better vegetative growth. This in turn produces more amounts of the photosynthate and is utilized for the development of shoots. Thus, the plant becomes taller. The results of this finding is in consistent with those reported by Rahman *et al*. (2004) in garlic, Zaman *et al*. (2011) in garlic and Alassaf (2013). However, this is in contrast to the studies where heights of onion increased with application of N at 100 kg /ha (Kumar *et al*. (1998), Samaila (2000), Khan *et al.* (2002) and Aliyu *et al.* (2007).

Diameter of the bulb

Plant Spacing

Table. 2 shows that the diameter of bulbs significantly ($P<0.05$) affected by spacing at 30, 75 and 90 DAP of crop growth. However, plant density did not influence the diameter of bulb/plant at 60, and 90 DAP (Table. 3). At 30 DAP, highest diameter of bulb was obtained at the spacing of 10 x 12 cm and 8x 8 cm. But this trend has changed at 75 DAP. At 75 DAP, highest diameter of bulb was found at the spacing of 10 x 12 cm and 10 x 10cm than 8 x 8 cm. As the plant density increased (closes pacing), the size of the bulb decreased. This might be due to the fact that at the highest density, competition for growth resources was greater. Thus, inadequate nutrients and space limited the enlargement of bulbs. Similar results have been reported by Farooq-Ch *et al*. (1990), Islam *et al*. (1999), and Katon *et al*. (2002).

Table: 1 Effect of spacing and levels of nitrogen on plant height (cm) at different stages of growth

Spacing (cm)	Nitrogen (kg/ha)	Days After Planting			
		30	60	75	90
8 x 8	180	15.60 a*	18.00 b	16.67 a	5.33ab
8 x 8	150	18.20 a	21.67 a	19.00 a	6.33 a
8 x 8	120	15.40 a	12.67 c	9.67 c	6.00 a
10 x 10	180	15.17 a	16.00 bc	13.67 b	5.33 ab
10 x 10	150	16.73 a	14.73 bc	10.67 c	6.33 a
10 x 10	120	16.03 a	14.00 c	9.00 c	2.33 b
10 x 12	180	16.53 a	14.34 c	11.50 bc	3.33 ab
10 x 12	150	16.78 a	14.34 c	11.33 bc	4.68 ab
10 x 12	120	17.77 a	15.00 bc	10.00 c	3.33 ab
Spacing		0.3728	0.0091	<.0001	0.0396
Nitrogen		0.5108	0.0095	<.0001	0.0682
Interaction		0.3943	0.0034	0.0013	0.2592
CV		11.01	11.95	12.29	33.37

**Means followed by the same letter in each column are not significantly different at p= 0.05*

Levels of nitrogen

Effect of nitrogen on diameter of bulb/plant is given in Table. 2. Levels of nitrogen significantly influenced the diameter of bulb/plant at all stages of growth. As the level of nitrogen increased from 120 to 150 kg N/ha, diameter of bulb also increased. A further increase in nitrogen decreased the diameter of the bulb (Table. 2). Therefore, the diameter of the bulb was highest at the 150 kg N/ha at all stages of growth. But this effect was not clear at 30 and 60 DAP. At harvest (90 DAP), highest diameter of bulb was recorded ($P<0.0001$) at 150 kg N/ha (Table. 2) and the lowest diameter of bulb/plant was obtained with the application of 120 kg N/ ha at all spacing tested. Therefore, this result suggests that application of nitrogen at the rate of 150 kg N/ha increased the diameter of bulb by 23% when compared to the nitrogen application at the 120 kg N/ha and the maximum diameter of the bulb was with 150 kg N/ha. 150 kg N/ha nitrogen was adequate to promote the growth of plants. This is agreement with the findings of Rahman *et al*. (2004), Setty *et al*. (1989). This is in contrast to the studies where 100 kg N/ha increased diameter of bulbs (Kumar *et al*. (1998), Khan *et al*., (2002) and Aliyu *et al.* (2008).

Interaction

There was no interaction between spacing and levels of nitrogen on diameter of bulb at any stages of growth (Table 2). The absence of interaction between spacing and levels of nitrogen cannot be explained but may be due shrinkage of bulb during later stages of crop growth.

Table: 2 Effect of spacing and levels of nitrogen on diameter of bulb at different Stages of growth

Spacing (cm)	**Nitrogen (kg/ha)**	**Days After Planting**			
		30	**60**	**75**	**90**
8 x 8	180	9.41^{a}	10.13^{a}	9.08^{c}	8.83^{dc}
8 x 8	150	9.17^{a}	11.00^{a}	11.50^{a}	11.75^{a}
8 x 8	120	8.09^{a}	8.66^{a}	8.16^{c}	8.20^{d}
10 x 10	180	7.23^{a}	10.66^{a}	10.93^{a}	10.80^{ab}
10 x 10	150	8.66^{a}	12.04^{a}	11.91^{a}	12.10^{a}
10 x 10	120	4.77^{b}	9.33^{a}	7.33^{c}	7.33^{d}
10 x 12	180	9.15^{a}	11.50^{a}	11.56^{a}	9.90^{bc}
10 x 12	150	8.11^{a}	10.00^{a}	10.50^{a}	11.67^{a}
10 x 12	120	8.42^{a}	8.84^{a}	8.06^{c}	8.30^{d}
Spacing		0.0393	0.6398	0.0104	0.4611
Nitrogen		0.012	0.0436	0.0002	<.0001
Interaction		1.98	0.673	0.1556	0.0924
CV		0.15	16.89	10.52	8.44

**Means followed by the same letter in each column are not significantly different at p= 0.05*

Fresh weight of bulbs

Interaction

It was noted that there was a significant variation ($P<0.05$) in weight of bulbs/ha among the treatments tested (Table. 3). It was observed that decreasing plant spacing (increasing the plant density) increased the bulb weight per unit area i.e. weight of bulbs/ha was highest at the closest spacing (8 x 8). When the plant spacing was decreased from 10 x 12 cm to 8 x 8 cm, weight of bulbs was increased by 18%. This is in agreement with the findings of Kumar *et al*., (1998), Resendle *et al*. (1999) and Jilani *et al*. (2010) who were reported that decreasing the plant spacing increases in total yield of onion.

The weight of bulbs is significantly affected by the levels of nitrogen (Table. 3). Increase in levels nitrogen from 120 to 150 kg N/ha, increased the yield (ha) of onion bulbs by 38 Mt/ ha (27%). A further increase in nitrogen from 150 to 180 kg/ha, significantly decreased the yield by 16 Mt/ ha (54%).

There was an interaction ($P<0.05$) between plant density and levels of nitrogen (Table. 3). Significantly ($P< 0.05$) higher weight of bulbs/ha was recorded with 8 x 8 cm at 150 kg N/ha. At all three spacing, the lowest weight of onion bulbs/ha was recorded with 120 kg N/ha. On the whole, highest yield/ha was recorded at the highest density (closest spacing – 8 x 8 cm) with 150 kg N/ha. It may be possible that at the highest densities (closest spacing), the contribution from each plant towards bulb formation is greater than widely spaced plants at the lowest densities.

The recommended spacing for onion in is Sri Lanka is 10 x 10 cm (Department of Agriculture, 2002). The yield at this density was 17% lower than the spacing at 8 x 8 used in this study. Nitrogen is one of the major plant nutrients required for vegetative growth in plants. An adequate amount of nitrogen leads to higher/better vegetative growth. When better vegetative growth is encouraged, relatively more of the carbohydrate will be synthesized and utilized for the development of shoots and the plant becomes taller. Nitrogen also causes better proliferation and distribution of roots in plants. Improved root development enhances the plant to absorb more water from the soil and enhances the uptake and utilization of other essential nutrients by increasing the root surface area. This results in higher number of leaves, LAI, diameter of bulbs, weight of leaves and dry matter (data not given) and increase in number of plants contributed to increase in yield with the application of 150 kg N/ha than in 180 and 120 kg N/ha.

When vegetative growth is encouraged by optimum level of nitrogen (150 kg N/ha) (Fig.1), more photosynthates will be produced. The excess photosynthates after utilizing for maintenance of plant, rest will be translocated to the storage organ. Thus, results in an increase in yield of onion plants (Table 3). In this study, nitrogen application at 150 kg N/ha resulted in higher yield than other levels tested. Similar results have been reported by Diaz-Perez *et al.* (2003), Singh *et al.* (2004), Rahman *et al* (2004), Zaman *et al* (2011) and Alassaf (2013). This is in contrast to the studies where the bulb yield of onion increased with 100 kg N/ha reported by Kumar *et al*. (1998); Samaila (2000); Aliyu *et al*. (2007); and Khan *et al*. (2002), and 200 kg N/ha reported by Neeraja *et al.* (2001) and Al-Moshileh (2001).

A quadratic relationship was observed between bulb yield and levels of nitrogen (Fig. 3). Relationship between levels of nitrogen and weight of bulbs was significantly varied in onion plants (Fig. 1). Higher coefficient of determination ($R^2 = 0.90$) indicated that the regression model was a good fit, which suggests that 90% variation in yield of onion bulb could be credited to the differences of nitrogen nutrition.

Relationship between the levels of nitrogen and weight of bulbs was significantly varied with spacing between onion plants (Fig. 1). At the spacing of 8 x 8 cm, the relationship between weight of bulbs and levels of nitrogen is described by the equation, $Y = 0.6583X^2 + 203.75X – 13487$ ($R^2 = 0.9083$) and at the spacing of 10 X 10 cm and 10 X 12 cm, the relationship is described by the equation $Y = - 1.3093X^2 + 406.94X – 29213$ ($R^2 = 0.8754$) and $Y = - 1.0546X^2 + 331.92X – 23842$ ($R^2 = 0.8901$) respectively (Fig. 1).

Optimum level of application of nitrogen at the spacing of 8x 8 cm, 10x10 cm and 10x12 cm was 154.83 kg/ha, 155.4 kg/ha, and 157.37 kg/ha respectively. According to this investigation, optimum level of nitrogen application increased with increasing spacing between onion plants (higher at lowest density or wider spacing). Higher level of nitrogen at lowest density (wider spacing) encourages weed growth. The result also revealed that at all the densities, the optimum level of nitrogen ranges between 154 to 157 kg N/ha.

Table 3: Effect of spacing and levels of nitrogen on total weight of bulb

Spacing (cm)	Nitrogen (kg/ha)		
	120	**150**	**180**
8 x 8	18.58^{bc}	22.63^{a}	14.83^{c}
10 x 10	17.33^{c}	22.17^{ab}	8.017^{d}
10 x 12	16.17^{c}	21.70^{ab}	7.67^{d}
Spacing		0.0168	
Nitrogen		<.0001	
Interaction		0.0337	
CV		12.6	

**Means followed by the same letter in each column are not significantly different at p= 0.05*

Optimum level of application of nitrogen at the spacing of 8x 8 cm, 10x10 cm and 10x12 cm was 154.83 kg/ha, 155.4 kg/ha, and 157.37 kg/ha respectively. According to this investigation, optimum level of nitrogen application increased with increasing spacing between onion plants (higher at lowest density or wider spacing). Higher level of nitrogen at lowest density (wider spacing) encourages weed growth. The result also revealed that at all the densities, the optimum level of nitrogen ranges between 154 to 157 kg N/ha.

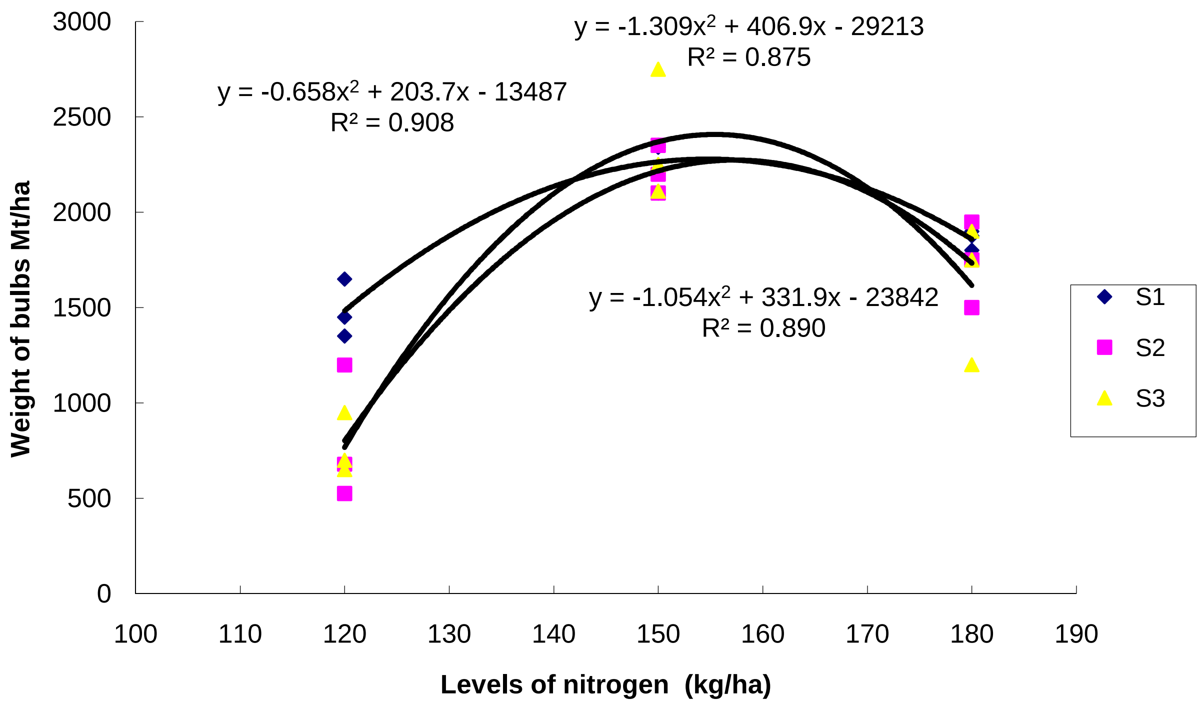

Fig. 1 Effect of spacing and levels of nitrogen on bulb weight

The average yield for the variety Vethalan as estimated by the Department of Agriculture is 20,000 kg/ha at the density of 10 cm x10 cm and nitrogen 150 kg/ha. However, in the present investigation on the average yield of 22.15 and 22.75 Mt/ha (fresh weight basis) was obtained at the spacing of 8 x8 cm and 10 x12 cm with 150 kg N/ ha.

Number of bulbs

Spacing

Number of bulbs per hectare at 60, 75 and 90 weeks after planting steadily increased with decreasing spacing at different stages of growth (Table. 4). Plant density was affected by the number of bulbs/ha at different stages (Table 4). At 60 DAP, highest number of bulbs/ha ($P<0.002$) was recorded at the closest spacing (8 x 8cm) and the lowest number was recorded at the widest spacing (10 x 12 cm).

Levels of nitrogen

Levels of nitrogen did not affect the number of bubs/ha at 60 DAP (Table 4).

Interaction

At 90 DAP, number of bulbs/ha was affected by the spacing. Highest number of bulbs was observed at 180 and 150 kg N/ha. At harvest (90 DAP), the number of bulbs/ha increased by 13% when the spacing was reduced from 10 x 12 cm to 8 x 8 cm (Table 4). Further increase from 10x 10 cm to 8 x 8 cm resulted in 61 % increase in number of bulbs. The number of bulbs/ha at the closest spacing (8 x 8 cm) was probably due to increase in the number of plants/ha (Table. 4). However highest number of bulbs was recorded at the closest spacing (8 x 8 cm) with 180 and 150 kg N/ ha.

It was reported that size of bulb and number of bulblets formed could be increased by additional application of nitrogen after planting (Gamiely *et al.,* 1991). Purse glove (1972) documented that onion is a heavy feeder and it gives good response to organic manures (addition of nitrogen).

Table: 4 Effect of spacing and levels of nitrogen on number of bulbs/ha ('000) at different stages of growth

Spacing (cm)	Nitrogen (kg/ha)	Days After Planting		
		60	75	90
8 x 8	180	8580[a]	8830[a]	9360[a]
8 x 8	150	8840[b]	9360[b]	8840[a]
8 x 8	120	7280[bc]	5720[cb]	5720[b]
10 x 10	180	5080b[c]	4666[cb]	5000[bc]
10 x 10	150	5000[bc]	4666[cb]	5000[bc]
10 x 10	120	5666[bc]	5000[cb]	4722[bc]
10 x 12	180	4666[bc]	4722[cb]	4722[bc]
10 x 12	150	4444[bc]	4722[cb]	4666[bc]
10 x 12	120	4999[c]	3888[c]	3611[c]
Spacing		0.0091	<.0001	0.0396
Nitrogen		0.0095	<.0001	0.0682
Interaction		0.0034	0.0013	0.2592
CV		11.95	12.29	33.37

**Means followed by the same letter in each column are not significantly different at p= 0.05*

CONCLUSION

The results showed that the different spacing and levels of nitrogen had significant effects on plant height, diameter, fresh weight and number of bulbs of onion. The results also indicated that increase in levels of nitrogen from 120 to 150 kg N/ha increased the bulb yield by 27%. A further increase in nitrogen level from 150 to 180 kg N/ha reduced the yield by 54%.

It is evident that the combination of close spacing (8 x 8 cm) with optimum level of 150 kg N/ha is the best choice for obtaining high yield in onion in the sandy regosols in the Batticaloa District.

REFERENCES

Agricultural Implementation Programmed. Eastern province, 2013.

Ali Alissa, M., 2013. Effect of irrigation interval and nitrogen fertilizer on growth and yield of onion (*Allium cepa* L.). International Journal of Environment and Water 2(5), 105-113.

Aliyu, U., Manga Ji, M.D, Yakubu, A.I. and Dikko, A.U., 2007. Correlation and path coefficient analysis for some yield related traits in onion (*Allium cepa* L.). Journal of Plant Science. 2(3), 366-369.

Al-Moshileh, A.M.P., 2001. Effect of nitrogen, phosphorus and potassium fertilizers on onion productivity in central region of Saudi Arabia. Assiut Journal of Agricultural Science 32, 291-305.

Amans, E.B., 1992. Fruit and Vegetable production, harvesting and storage. In: A.O. Onabolu and A. I. Ogunmefun (Eds.). Food Crops Production Utilization and Nutrition. Proceedings of NICEF/Inst. of Agricultural Research Workshop, pp. 34-46.

Brewster, J.L., 1994. Onion and other vegetable Alliums. Univ. Press, Cambridge, Mass

Coelo, R.F.V.A.B. Souza and Conceicao, M.A.F., 1996. Performance of onion crops under threeirrigation regimes and five spacings. Pesquisa Agropecuaria Brasilcira 31(8), 585-591.

Craig, W.J., 1999. Health-promoting properties of common herbs. American Journal of Clinical Nutrition, 70(3), 491S-499.

Dawar, N. M., Wazir, F.K., Dawar, M. and Dawar, S.H., 2007. Effect of planting density on growth and yield of of onion varieties under climatic conditions of Peshawar. Sarhad Journal of Agriculture 23(4), 912-917.

De Alwis, K.A. and Panabokke, C.R., 1972. Handbook of the soils of Sri Lanka, Soil Science Society of Ceylon. Soil Science Society of Ceylon 2**,** 1. 97.

Department of Agriculture, 1990. Crop Recommendations Technoguide, Sri Lanka, p.60.

Department of Agriculture, 2012. Onion Production in Sri Lanka.

Diaz-Perez, J.C., Purvis, A.C, and Paulk, J.T., 2003. Bolting, yield, and bulb decay of sweet onion as affected by nitrogen fertilization. Journal American Society Horticultural Science. 128**,**144-149.

FAOSTAT, 2013. Food and Agriculture Organization of the United Nation, Rome.

Farooq-Ch, M., Mahmood K. Khan, M.A. and Qadir, A., 1990.Effect of plant density on plant growth, size and yield of onion. Pakistan Journal of Agricultural Research. 11(4), 239-242.

Gamiely, S., Randle, W.M., Mills, H.A., Smittle, D.A, and Banna, G.I., 1991. Onion plant growth, bulb quality, and water uptake following ammonium and nitrate nutrition. Horticultural Science. 26, 1061–1063.

Halvorson, A.D., Bartolo, M.E., Reule, C.A. and Berrada, A., 2008. Nitrogen effects on onion yield under drip and furrow irrigation. Agronomy Journal. 100(4), 1062 - 1069.

Islam, M.S., Khan, B.R. and Rashid, M,H., 1999: Irrigation scheduling for onion. Bangladesh Journal of Agricultural Research. 24(2), 233–240.

Jilani, M.S., Ahmed, P., Waseem, K. and Kiran, M., 2010. Effect of plant spacing on growth and yield of two varities of onion (*Allium cepa* L.) under the agro-climatic condition of d. i. khan. Pakistan Journal of Science. 62(1), 37-41.

Kanton, R.A.L., Abbey, L., Hilla, R.G., Tabil, M.A. and Jan, N.D. 2003. Density affects plant development and yield of bulb onion (*Allium cepa* L.) in Northern Ghana. Journal of Vegetable Crop Production. 8(2), 15-25.
Doi: 10.1300/j068v08n02_03.

Khan, H., Iqbal, M., Ghaffoor, A. and Waseem, K**.** 2002. Effect of various plant spacing and different nitrogen levels on the growth and yield of onion (*Allium cepa* L.). Journal of Biological Science. 2(8), 545- 547 .

Kumar, H., Singh, J.V., Ajay, K., Mahak, S., Kumar, A, and Singh, M. 1998. Studies on the effect of spacing on growth and yield of onion (*Allium cepa*L.) cv Patna Red. Indian Journal of Agricultural Research. 2**,** 134 -138

Neeraja, G., Reddy, K.M., Reddy, M.S. and Rao, V. P. 2001. Influence of irrigation and nitrogen levels on bulb yield, nutrient uptake an nitrogen use efficiencies in rabi onion (*Allium cepa*). Indian Journal Agricultural Sciences. **7,** 109-111.

Onion Health Research, 2013. (Accessed on 24th Feb. 2015).
http://www.onions-usa.org/all-about-onions/onion-health-research

Purseglove, J.W. 1972. *Tropical Crops Monocotyledons*. Longman Singapore Publishers, PTC Ltd, p. 86-90.

Rahman, M.H., Rahim, M.A, Shah, M. T. A., Hossain, M.M. and Islam, M. R. 2004. Effect of clove size and nitrogen on the growth and yield of garlic *(Allium sativum* L.), Bangladesh Seed Science and Technology. 8(1&2), 21-25.

Randle, W.M. 2000. Increasing nitrogen concentration in hydroponic solutions affects onion flavor and bulb quality. Journal of the American Society for Horticultural Science. 125, 254–259.

Raun, W.R, and Johnson, **G.V.** 1999. Improving nitrogen use efficiency for cereal production. Agronomy Journal. 91, 357-363.

Reddy, G.B. and Reddy, M.S. 1998. Effect of organic manures and nitrogen levels on soil available nutrients in maize soyabean cropping system. Journal of Indian Society of Soil Sciences. 46(3), 474-476.

Resende, G.M., Costa, N.D. and Pinto, J.M.1999. Productivity and post-harvest quality of onion bulbs with nitrogen and potassium. Horticultura Brasila. 26(3), 388-392.

Samaila, A. 2000. Effect of planting patern and fertilizer rates in onion (*Allium cepa* L.) and pepper (*Capsicum annum* L.) mixed crop. Seminar Paper Presented to the Ahmadu Bello University, Zaria.

Setty, B.S., Sulikeri, G.S. and Hulamani, N.C. 1989. Effect of N, P and K on growth and yield of garlic *(Allium sativum* L.). Karnataka Journal of Agricultural Sciences. 2(3), 160-164.

Singh, S., Yadav, P.K., and Singh, B. 2004. Effect of nitrogen and potassium on growth and yield of onion (*Allium cepa* L.) Cv. Pusa Red. Haryana Journal of Horticultural Science. 33(3&4), 308-309.

Zaman, M.S., Hasham, M.A., Jahiruddin, M. and Rahim, M.A. 2011. Effect of nitrogen for yield maximization of garlic in old Brahmapatra flood plain soil. Bangladesh Journal of Agricultural Research. 36(2), 357-367.