**Proceedings of Pakistan Society for Horticultural Science**
2nd International Conference on Horticultural Sciences, February 18-20, 2016
Theme: Production Challenges and Food Security
Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Punjab 38040, Pakistan

# Enhancement of Yield and Quality of Onion by Foliar Application of Indole-3-Butyric Acid and 2,4-Dichlorophenoxyacetic Acid

Muhammad Irfan Ashraf[1], Chaudhary Muhammad Ayyub[2], Karm Yar Abbasi[3], Mujahid Ali* [4] and Shagufta Kamal[5]
Institute of Horticultural Sciences, University of Agriculture, Faisalabad
Email: mujahidali2263@gmail.com (M.A)

## Abstract

Plant growth regulators are being used for enhancing qualitative and quantitative attributes of vegetables. To investigate the improvement in yield and quality of onion a field experiment was conducted. Indole-3-butyric acid (IBA) and Dichlorophenoxyacetic acid (2,4-D) each with 2 ppm and 4 ppm were exogenously applied along with control. The results indicated that IBA and 2,4-D with different concentrations led to significant increases in vegetative growth; leaf length, plant height, number of leaves per plant, fresh and dry weight of leaves, fresh and dry weight of bulbs, bulbs diameter, bulbs neck diameter, bulbs moisture percentage, bulbs dry matter percentage and biochemical attributes like total soluble solids, titratable acidity and vitamin C contents of onion bulbs. IBA and 2,4-D in high concentrations gave better results than other treatments. 4 ppm of 2,4-D caused increase in number of leaves per plant, fresh weight of leaves and bulbs neck diameter as well as biochemical constituents of onion bulbs. IBA with 4 ppm also showed significant increase in the following vegetative growth characters like; leaf length, plant height, weight of dry leaves, leaf width and bulbs dry matter percentage. It was concluded that quality of onion was superior with the foliar application of 2,4-D as compared to IBA.

## INTRODUCTION

Onion belongs to the family amaryllidaceae and one of the most important monocotyledonous, cross pollinated and cool season vegetable crop. Onion is also known as "Queen of the Kitchen". Onion is a rich source of proteins, carbohydrates and vitamin C besides minerals like phosphorus and calcium. Onion is well known for its extreme pungency, flavour and also beneficial for stored grains protectant (Jaggi, 2005). Onion has its specific flavor, cooked alone as a vegetable as well as used in dishes, soups, sandwiches and salad as it contains some starch, protein, sugar and vitamins A, B and C (Jilani *et al.*, 2010). Onion can be helpful as guard against number of chronic diseases because it contains flavonoid quercetin that protects from cataracts, cancer and cardiovascular disease. Organosulfur compounds also found in onion those one is helpful for reducing blood pressure and cholesterol levels. The onion is anthelmintic,

anti-inflammatory, antiseptic, carminative, diuretic, febrifuge, hypoglycaemic, hypotensive and work against angina, arteriosclerosis and heart attack (Kumar *et al.,* 2010). Onion is good source of certain minerals, vitamins and carbohydrates. Most fraction of carbohydrate is dietary fiber. An average 100 g fresh sample consists of 90% water, 1.5 g of soluble proteins and 0.1 g of fat and about 8.7 g of carbohydrate (Peirce, 1987). Onion is primarily grown for their uses such as food, adding flavors for food and taste as well as used for processing items such as pickling, freezing, dehydration, oil extraction. Young and healthy green leaves with their white bases can also be eaten raw as salad. The importance of varieties choice when onions for consumption as cultivars differ in flavor (Randle & Bussard, 1993 and Randle *et al.*, 1998). Onions are also a big source of Vitamin C and E (Made *et al.,* 1994; Griffiths *et al.*, 2002; Tabor *et al.*, 2004; Block, 2005 & El Assi). All these characteristics of onions have been found to contribute to the high demand for onions.

Among all fresh vegetables, onion is a unique item of agriculture that exports earning highly foreign exchange for the country and almost for about 71% of the total foreign exchange earnings within all fresh vegetables (Sirohi and Behera, 2002). Onions are grown in every part of the world where plants are farmed and can be grown from seeds. It is grown in 175 countries of the world and with total production of 74 million tons. China, India, United States, Turkey and Pakistan are the leading producers of onion. It shows great variation in many characteristics such as size, colour, shape and pungency (Griffiths *et al.,* 2002). Onion production is the second after tomato regarding to annual production of world vegetables (Karim and Ibrahim, 2013). It has 46.06 m tones yield in India over an area of 2.69 million ha. In Karnataka, it contains 1.33 lacs ha area with the total yield of 8.83 lacs tones (Anon., 2002). In Pakistan, it is cultivated an area of 105.8 thousand hectares along with 1563.6 thousand tons aspect to total production. The average yield of bulbs of onion per hectare is 14.8 tones which is low and uneconomical for commercial production.

In Pakistan area under onion cultivation is 143.7 thousand hectares with a production of 1892 thousand tones during 2010-11. It is grown in all four provinces of Pakistan. The average per hectare yield of onion in Pakistan is quite low in comparison with that of the other neighboring countries like China, India and Bangladesh (FAOSTAT, 2012). Number of authors reported that foliar spray of growth regulators increased i.e onion yield (Singh *et al.,* 1994). However, the researches carried out to explore feasibility of using growth regulators in increasing the yield of onion are not adequate, especially in conditions of Pakistan. Although, most of these experiments were based on the foliar application of the growth regulators, there are reports that pre-sowing treatments are also effective in enhancing plant growth, yield and biochemical constituents.

Growth substances are used to regulate growth and improve productivity and quality of various plant species when applied in minute quantity. Indole-3-butyric acid (IBA) is an auxin, used to enhance and accelerate the formation of roots of young plant, to regulate growth of flowers and fruits for increasing crop yields. Early root development was observed by IBA as compared to untreated plants of datepalm (Afzal *et al.,* 2011), greater number of bud initiation (Krapiec *et al.*, 2003), enhance rooting percentage (Laubscher and Ndakidemi, 2008). $GA_3$ and IAA improved bulb diameter, bulb weight, number of roots and root length. Greater bulb diameter and weigt were found significantly increased at 200 ppm of $GA_3$ and IAA (Hye *et al.*, 2002).

Keeping these in view, the present experiment was conducted to study the response of different concentration of IBA and 2,4-D on growth, yield and quality of onion and the role of IBA and 2,4-D in modifying the morphological characters and yield of Onion.

## MATERIAL AND METHODS

Present research studies were carried out at Vegetable Research Area, University of agriculture, Faisalabad, during 2013-14 to study the effect of foliar application of different concentration of Indole-3-Butyric acid and 2,4-Dichlorophenoxy acetic acid on morphological and biochemical parameters of onion. Materials for this research consist of plants of onion cultivar "Desi Red" and different concentration of IBA and 2,4-D. Foliar application of different concentration of these growth regulators were applied 30 days after onion seedling transplanting.

Some morphological traits of onion like plant height, leaf length, leaf width and number of leaves were calculated before harvesting. Whereas data of these characters were collected after one week interval. After 100 days from transplanting, crop was harvested and following morphological parameters like fresh weight of bulb, dry weight of bulb, bulb diameter, neck diameter, bulb moisture percentage, total soluble salts (TSS), vitamin C and titratable acidity were calculated.

Transplanting was done on ridges of 75 cm wide and plant to plant distance was maintained at 15.25 cm. Transplanting of seedlings was taken place on ridges. Ridges were made 75 cm wide and plant to plant distance was 6 inches. Foliar spray with different concentration of IBA and 2, 4-D (50 ppm and 100 ppm of each) were applied after 30 days of transplanting. The experiment was laid out according to Randomized Complete Block Design (RCBD) with five treatments. Phosphorus, potassium and one third of nitrogen were applied at the time of land preparation while remaining nitrogen was applied throughout the season as split doses to the crop. The first irrigation was applied immediately before transplantation while subsequent irrigations were applied as per crop requirement. Hoeing and weeding were practiced according to requirement. Dithane M-45 as fungicides and Imidacloprid as insecticides were applied to control disease and insect infestation.

Treatments to be included in this experiment are given $T_0$ (Control), $T_1$ (IBA 50 ppm), $T_2$ (IBA 100 ppm), $T_3$ (2, 4-D 50 ppm) and $T_4$ (2, 4-D 100 ppm). Data were recorded for the following morphological parameters of the onion plant. Height of the plant was calculated with a measuring tape. The height was recorded by placing the measuring tape from soil surface at the base of the plant up to the tallest growing point on the randomly selected plants: their average were calculated and analyzed statistically. Length of leaves was measured from base to the tip of the leaves at 40 and 60 days after transplanting and at harvest and the leaf length was expressed in cm. Leaf width was measured at three different points and their average is calculated. It is expressed in cm. The numbers of the leaves were counted on randomly selected plants at the time of complete maturity their average was calculated and analyzed statistically. Bulb fresh weight of the plant was calculated after harvesting by digital weight balance in grams (gm) from randomly selected plants and their average were calculated and analyzed statistically. Bulbs were harvested and dried. Dry weight of the root was calculated after 72 hours drying the bulbs in an oven at 60$^{o}$C. Dry weight was calculated by digital weight balance. Their averages were calculated and analyzed statistically. The diameter

of the onion bulb of five randomly selected plants after harvesting was measured with the help of vernier caliper in cm in each treatment, then mean values were calculated. The neck diameter of bulb of five randomly selected plants after harvesting was measured at two different points i.e. Attachment of the bulb and 4 cm far from the attachment and average neck diameter was expressed in cm. Bulb moisture percentage was calculated by using the following formula:

$$\text{Bulb moisture (\%)} = \frac{\text{Bulb fresh weight} - \text{bulb dry weight}}{\text{Bulb fresh weight}} \times 100$$

Yield per hectare was calculated by taking the yield from 1 $m^2$ area of each treatment and then by multiplying with 10000 $m^2$**.**

### Biochemical Parameters

***Total Soluble Solids***: Total soluble solids were determined by using refractometer. Five bulbs were taken from each treatment. A drop of the representative sample of bulb juice was placed on prism and readings were noted.

***Titratable acidity (mg/L)*:** It is measured by determining the concentration of titratable hydrogen ions in juice. It depends upon the concentration of tartaric acid and bitartratemalic acid. It is usually expressed as g/l as tartaric acid and normally determined by titration with Sodium Hydroxide (NaOH) to a pH end-point of 8.2.

***Vitamin C (mg/L):*** Vitamin C was measured by DCPIP (dichlorophenolindophenol) method. The principle of this method is a titration with dichlorophenolindophenol (or phenol-indo-2:6-dichlorophenol, also known as DCPIP). Ascorbic acid reacts with DCPIP, changing the color from blue to colorless. They react in a 1:1 fashion, so if a known quantity of DCPIP solution reacts with the plant tissue extract, the quantity of DCPIP used gives a direct measure of the quantity of ascorbic acid present. Onion 10 gm fruit sample was taken with 2.5 ml of 20% metaphosphoric acid and distilled water was then added up to 100 ml mark. 10 ml of the suspension was titrated with standard 2,6-dichloroindophenol freshly prepared dye untill light pink colour persisted for 15 sec. Vit C in each sample was then calculated as mg per 100 grams. Their average was calculated and analyzed statistically.

### Statistical Analysis

The experiment was executed in open field conditions according to Randomized Complete Block Design (RCBD) having five treatments with different concentrations of IBA and 2,4-D. Each treatment was replicated for four times. Data were subjected to analysis of variance technique and difference among treatments was determined by (LSD) test at 5% probability level (Steel *et al.*, 1997).

## RESULTS

Data regarding vegetative growth, yield and biochemical parameters were taken during the growth period and after harvest. Leaf length in all treatments differ significantly and was maximum (47.28 cm) at 100 ppm IBA as compared to control (36.71 cm). The second-best treatment was 100 ppm 2,4-D in which 42.38 cm leaf length was observed. Plant height also showed significant results for the treatments. All treatments differ significantly with respect to plant height and it was maximum (52.46 cm) at 100 ppm IBA as compared to control (41.18 cm). However, all other treatments behind

statistically were alike. The second-best value (48.14 cm) was given by 100 ppm 2,4-D (Table 1).

Number of leaves per plant of onion plants showed that two levels of IBA and 2,4-D did not have significant effect on number of leaves per plant. Meanwhile maximum number of leaves per plant (9.0) were recorded at 100 ppm 2,4-D plant, followed by (8.0) at 100 ppm. 100 ppm 2,4-D and 100 ppm IBA were statistically at par with each other. Plants treated with 50 ppm IBA recorded optimum number of leaves per plant. Minimum number of leaves were recorded in both 50 ppm 2,4-D and control and both were statistically alike. Leaf width of onion cultivar desi red was demonstrated significantly results with different leaves width. All treatments differ significantly with respect to width and it was maximum at 100 ppm IBA as compared to control. However, all other treatments behind this statistically were not same. The second-best treatment 100 ppm 2,4-D and then 50 ppm IBA, and 50 ppm 2,4-D in descending order respectively. Minimum leaf width was recorded at control (Table 1).

Regarding fresh bulb weight fresh bulb weight was illustrate highly significant results. Maximum bulb fresh weight (141.72 g) was observed with 100 ppm 2,4-D behaved statistically alike. All treatments showed better results than 50 ppm IBA gave 16.84 g. The application 100 ppm 2,4-D as compared to control (139.64 g). The second-best treatment was control in which bulb fresh weight was followed by 100 ppm 2,4-D and both these treatments were behaved statistically alike. However, the lowest bulb weight (111.88 g) was recorded for 100 ppm IBA (Table 1).

**Table 1:** Effect of indole-3-butyric acid and 2,4-dichlorophenoxyacetic acid on morphological parameters of onion Leaf Length plant height, number of leaves/plant, leaf width, fresh bulb weight.

| Treatments | Leaf Length (cm) | Plant Height (cm) | Number of leaves/plant | Leaf width (cm) | Fresh bulb weight (g) |
|---|---|---|---|---|---|
| **Control** | 36.78 c | 41.18 d | 7.6 c | 0.87 d | 139.64 a |
| 50 ppm, IBA | 41.26 b | 45.94 c | 8.4 b | 1.08 b | 134.2 b |
| 100 ppm IBA | 47.28 a | 52.46 a | 8.8 ab | 1.2 a | 111.88 c |
| 50 ppm, 2,4-D | 40.38 b | 45.1 a | 7.2 c | 0.95 c | 141.72 a |
| 100 ppm 2,4-D | 42.38 b | 48.14 b | 9 a | 1.14 ab | 139.42 a |

Figures sharing same letters do not differ from each other at $P \leq 0.05$ according to LSD test.

Dry bulb weight was illustrated highly significant results for the treatments. All treatment means demonstrated that maximum bulb dry weight (21.32 g) were observed at control. The next best treatment was 100 ppm 2,4-D in which 20.94 g bulb dry weight was observed. Both control and Dry leaf weight of onion cultivar Desi Red were recorded. The comparison of average leaf dry weight of onion gained by the application of four different treatments. Statistically significant results were achieved as compared to control. Maximum leaves dry weight (5.52 gm) was recorded by 100 ppm IBA followed by 100 ppm 2,4-D with 5.50 gm both these are non-significant to each other and significant to other. Plants treated with 50 ppm IBA and 50 ppm 2,4-D showed statistically similar response in this regard. Minimum (5.14 gm) dry leaf weight was recorded by at control (Table 2).

Average bulb diameter is very important characteristic of onion plant because it is directly proportional to yield. Average bulb diameter was significant results for the treatments. The values visualized highly significant results of 50 ppm IBA over other treatments. 100 ppm IBA were placed in second best position followed control and both treatments showed statistically similar response. Maximum bulb diameter (7.62 cm) was observed with the application 50 ppm IBA as compared with control (6.9 cm). The second-best treatment was 100 ppm IBA in which (6.9 cm) was observed. Bulb diameter was also satisfactory in treatment at control and 100 ppm IBA and both were statistically alike. These studies showed that IBA application appeared better than control and 2,4-D. Bulb neck diameter had highly significant results for all the treatments. 50 ppm 2,4-D were placed in second position while 50 ppm IBA occupied third position whereas control retained at the bottom. Maximum bulb neck diameter (1.84 cm) was observed with the application 100 ppm 2,4-D as compared with control (1.4 cm). The second-best treatment was 100 ppm 2,4-D with 1.68 cm bulb neck diameter. Bulb neck diameters were statistically similar in treatment 100 ppm IBA and control, respectively (Table 2).

Bulb moisture percentage illustrated that maximum bulb moisture percentage (86.06%) was observed with the application of 50 ppm 2,4-D followed by 50 ppm IBA with (85.80%) moisture. Both these treatments behaved statistically alike. Minimum (84.51%) in treatment 100 ppm IBA which was statisticallyat par with control. The second treatment was 50 ppm IBA in which 85.80% was observed. Bulb moisture was also satisfactory in treatment 100 ppm 2,4-D. Comparison of means of all treatments revealed that 2,4-D and IBA both at 50 ppm presented the best results. Average bulb yield was showed highly significant results for all the treatments. Treatment 100 ppm IBA was given 13.88 tons/ha yield and occupied second position in table. While 50 ppm IBA (13.15 tons/ha) was at third position. So, 50 ppm IBA and 100 ppm IBA was statistically at par with each other and showed superiority over control and 50 ppm 2,4-D.

**Table 2:** Effect of Indole-3-butyric acid and 2,4-Dichlorophenoxyacetic acid on dry bulb weight, bulb diameter bulb neck diameter, bulb moisture (%), yield/ha.

| Treatments | Dry bulb weight (g) | Bulb diameter (cm) | Bulb neck diameter (cm) | Bulb moisture (%) | Yield ton/ha |
|---|---|---|---|---|---|
| **Control** | 21.32 a | 6.9 b | 1.4 d | 84.73 bc | 11.75 a |
| **50 ppm, IBA** | 19.04 c | 7.62 a | 1.52 c | 85.8 a | 13.15 b |
| **100 ppm IBA** | 16.84 d | 6.9 b | 1.43 d | 84.51 c | 13.88 bc |
| **50 ppm, 2,4-D** | 19.74 b | 6.62 c | 1.68 b | 86.06 a | 12.71 d |
| **100 ppm 2,4-D** | 20.94 a | 6.46 c | 1.81 a | 84.99 b | 14.78 e |

Figures sharing same letters do not differ from each other at $P \leq 0.05$ according to LSD test.

## Biochemical Attributes

Among all treatments highest mean value for TSS was recorded in treatment 100 ppm 2,4-D (2.96) and the lowest mean value (2.08) was recorded in 100 ppm IBA. The other values for control, 50 ppm IBA and 50 ppm 2,4-D were as 2.78, 2.22 and 2.32, respectively. This revealed that highly significant results for all treatments for total soluble solids (TSS). All the treatments were statistically significant to each other. The values for titratable acidity visualized highly significant results at 100 ppm 2,4-D over all other treatments. 100 ppm IBA, 50 ppm 2,4-D and control were placed in second, third

and fourth positions, respectively and statistically behaved alike. Whereas, 50 ppm IBA gave the lowest value for titratable acidity. Vitamin C contents of onion variety desi red was recorded maximum vitamin C (0.602 mg) in 100 ppm 2,4-D as compared to control having 0.558 mg. 100 ppm IBA and 50 ppm 2,4-D having third and fourth positions, respectivel

**Table 3:** Effect of Indole-3-butyric acid and 2,4-Dichlorophenoxyacetic acid on biochemical parameters of onion.

| Treatments | T.S.S (°Brix) | T.A (mg/L) | Vit. C (mg) |
|---|---|---|---|
| Control | 2.78 b | 0.25 b | 0.56 b |
| 50 ppm IBA | 2.22 d | 0.21 c | 0.38 d |
| 100 ppm IBA | 2.08 e | 0.25 b | 0.39 c |
| 50 ppm 2,4-D | 2.32 c | 0.25 b | 0.39 cd |
| 100 ppm 2,4-D | 2.96 a | 0.28 a | 0.60 a |

Figures sharing same letters do not differ from each other at $P \leq 0.05$ according to LSD test

## DISCUSSION

In present study leaf length in all treatments differ with respect to leaf length and it was maximum at 100 ppm IBA as compared to control. The second-best treatment was 100 ppm 2,4-D in which 42.38 cm leaf length was observed. Plant height also showed significant results for the treatments. All treatments differ significantly with respect to plant height and it was maximum with 100 ppm IBA as compared to control. However, all other treatments behind were statistically alike. The second-best value was given by 100 ppm 2,4-D.

Our results are strengthened by Amin *et al.*, 2007 who reported that foliar application of IBA shows significant increases in plant height, vegetative growth, leaf area, number of leaves, fresh and dry leaves weight, bulb diameter, bulb length and bulb weight and by increasing concentration would also increased photosynthetic pigments, yield, biochemical constituents and quality.

The present study results are in accordance with Ateeq *et al.* (2001) who reported that higher concentration of 2,4-D can cause morphological changes in *Allium cepa* L. at 15-20 ppm. It is indicated that growth regulators spray was showed to be more useful than dipping of root. Ethrel (25 ppm) spray gave most bulb production and plant height in onion. Our findings about increase in bulb weight and diameter are in line with Tiwari *et al.*, 2003 they revealed that application of $GA_3$ (50 ppm) gave maximum number of leaves per plant both in the form of spray and by dipping of roots.

Indole-3-butyric acid (IBA) is an auxin, used to enhance and accelerate the formation of roots of young plant, to regulate growth of flowers and fruits for increasing crop yields. Early root development was observed by IBA as compared to untreated plants of datepalm (Afzal *et al.*, 2011), greater number of bud initiation (Krapiec *et al.*, 2003), enhance rooting percentage (Laubscher and Ndakidemi, 2008) was also observed in present study.

## CONCLUSION

Plant growth regulators IBA and 2,4-D both gave better results for growth and yield for onion crop, Whereas, quality of onions was also superior with the application of 2,4-D as compared to IBA.

## REFERENCES


Afzal, M., M.A. Khan, M.A. Pervez and R. Ahmed. 2011. Root induction in the aerial offshoots of date palm *Phoenix dactylifera* L. cultivar, Hillawi. Pak. J. Agri. Sci. 48(1): 11-17.

Amin, A., A. El-Sh., M. Rashad and H.M.H. El-Abagay. 2007. Physiological effect of indole- 3 - butyric acid and salicylic acid on growth, yield and chemical constituents of onion plants. J. Appl. Sci. Res. 3(11):1554-1563.

Ateeq, B., M.A. Farah, M.N. Ali and W. Ahmad. 2001. Clastogenicity of pentachlorophenol, 2,4-D and butachlor evaluated by Allium root tip test. Mutation Res.514:105-113.

Block, E. 2005. Biological activity of allium compounds: recent results. Acta Hort. 688:41-57.

Cheema, K.L., A. Saeed and M. Habib. 2003. Effect of sowing date on set size in various cultivars of onion *Allium cepa* L. Int. J. Agric. Biol. 5:185-187.

El assi, N. and A. Abu-rayyan. 2007. Yield and quality of onion bulbs as affected by manure applications. Acta Hort.741:265-271.

FAO. 2012. Production Yearbook for 2012. Food Agri. Org. United Nations.

Fritsch, R.M. and N. Friesen. 2002. Evolution, domestication and Taxonomy. In: *Allium* Crop Science, Recent Advances. (Ed. H.D. Rabinowitch and L. Currah). 5-30. CABI Publishing, Oxon.

Griffiths, G., G. Trueman, T. Crowther, B. Thomas and B. Smith. 2002. Onions a global benefit to health. Phytother. Res. 16:603-615.

Hye, M.A., M.S. Haque and M.A. Karim. 2002. Influence of growth regulators and their time of application on yield of Onion. Pak. J. Biol. Sci. 5(10):1021-1023.

Jaggi, R.C. 2005. Sulphur as production and protection agent in onion *Allium cepa*. Indian J. Agric. Sci. 75(12):805-808.

Jilani, M.S., P. Ahmed, K. Waseem and M. Kiran. 2010. Effect of plant spacing on growth and yield of two varieties of *Allium cepa* L. Pak. J. Sci. 62(1):217-223.

Karim, S.M.R. and N.R. Ibrahim. 2013. Effect of planting time, day length, soil pH and soil moisture on Onion. IJBPAS. 2(4):807-814.

Krapiec, P.V., M.A. Milaneze and M.D.P.D. Machado. 2003. Effects of different combinations of growth regulators for bud induction from seedlings of *Cattleyawalkeriana* Gardner (Orchidaceae). Acta Sci. Biol. Sci. 25(1):179-182.

Kumar, K.P.S., D. Bowmik, S. Chiranjib, K. Biswajit and P. Tiwari. 2010. *Allium cepa*: A traditional medicinal herb and its health benefits. J. Chem. Pharm. Res. 2(1):283-291.

Laubscher, C.P. and P.A. Ndakidemi. 2008. Rooting response under shade using IBA growth regulators and different growth mediums on *Leucadendron laxum* (Proteaceae). Afr. J. Agri. Res. 3(10):740-746.

Made, J.M., B.S. Wright and P. Maramba. 1994. Onion production and constrains in Zimbabwe: with specific reference to the agricultural development authority (ADA). Acta Hort. 358:349-351.

Peirce, L.J. 1987. Vegetables characteristics, production and marketing. 217-219. John Wiley and Sons. 605 Third Ave. New Yark.

Randle, W.M. and M.L. Bussard. 1993. Pungency and sugars of short day onions as affected by sulfur nutrition. J. Amer. Soc. Hort. Sci.118:766-770.

Randle, W.M., D.A Kopsell, D.E. Kopsell, S.L. Snyder. and R. Torrance.1998. Field sampling short day onions for bulb pungency. Hort. Tech. 3:329-332.

Sirohi, P. S. and T.K. Behera. 2003. Indian vegetable export: present status and future strategies. Indian Hort. 3(31):27-31.

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1997. Principles and Procedures of Statistics: A Biometrical Approach, 3rd ed. McGraw Hill Book Co., New York, USA.

Tabor, G., D. Getahun and A. Zelleke. 2004. Influence of storage duration on field sprouting, maturity and yield of some garlic *Allium sativum* L. cultivars at DebreZeit, Ethiopia. J. Hort. Sci. Biotech. 79:871-876.