Iran. J. Ichthyol. (Special Issue 1, 2022): 127-132

P-ISSN: 2383-1561; E-ISSN: 2383-0964
http://www.ijichthyol.org

Research Article

Effects of nitrogen doses and organic Alga 600 fertilizer on spinach, *Spinacia oleracea* growth and yield

Esraa Abd-Alhuseein JASIM*, Kamal Benyamin ESHO

Department of Horticulture and Landscape Design, College of Agriculture and Forestry, Mosul University, Mosul, Iraq.
Email: esraa.aj@uomosul.edu.iq

Abstract
This study was aimed to study the impacts of nitrogen and organic fertilization on the growth and yield of the spinach**,** using two levels of N (Urea) (0 and 40kg/donum) and organic fertilizer Alga 600 at (0, 2, 4, and 6g/L.). The results showed that the application of 40kg N /donum had a significant effect on the leaf length, chlorophyll, fresh weight plant, total yield kg/ha., inflorescences length, and seeds weight/plot. Application of Alga 600 at 6 gm/l had a significant increase in most studied traits except the no. of inflorescences/plant and weight of 100 seeds. Based on the findings, the interaction between 40kg N /donum and 6g/l of Alga600 revealed a significant increase in leaf length (cm), leaves number/plant, chlorophyll, plant weight (g), total yield (kg/ha). Inflorescences length (cm), seed weight /plot, seeds weight/plant (g).

Keywords: Seedlings, Citrus, Foliar spraying, Amino acids, Vegetative growth.

Citation: Jasim, E.A. & Esho, K.B. 2022. Effects of nitrogen doses and organic Alga 600 fertilizer on spinach, *Spinacia oleracea* growth and yield. Iranian Journal of Ichthyology 9(Special issue 1, 2022): 127-132.

Introduction

Spinach, *Spinacia oleracea* L., is a leafy vegetable crop, which belongs to the Chenopodiaceae family, and includes the chard and beets. Its original habitat is western Asia, especially southern Pakistan, Afghanistan, and Iran (Hassan 2003). The Arabs transferred spinach cultivation to Andalusia in 1100 AD, and its cultivation had spread to the rest of Europe and America (Ryder 1979). It also has a high nutritional value, and its cooked leaves are eaten, as it contains nutrients, including protein, fat, carbohydrates, fiber, ash, calcium, phosphorous, iron, sodium, potassium, manganese, vitamin A, thiamine, riboflavin, niacin, and ascorbic acid, and it is rich in vitamin K, which contains Phylloquinone, which is the precursor for vitamin k (Watt & Merrill 1963; Koivu et al. 1999).

Spinach yield depends on the vegetative growth that could be expressed based on the number of leaves, plant height, etc. The nitrogen supply of such a leafy vegetable crop leads to productivity due to the relatively higher demand for this element (Conte et al. 2008). Spinach can be defined as a long-day plant that tends bolting throughout the summer (Bergquest et al. 2005). Chlorophyll can be used as one of the parameters for the quality evaluation of freshly-cut vegetables (Bacchiocca & Ninfali 2004).

Nutrition has an important impact on the quality and yield of the crop (Sisson et al. 1991; Lemaire & Gastal 2002; Wang et al. 2002). The fertilization of the nitrogen results in increasing the foliage that reduces the intensity of the light around the plant that can impact flavonoid compound concentrations (Kader & Lee 2000). Abdel-Kader et al. (2007) indicated that the spinach yield with 50% N organic +50% N mineral treatments was higher. The high spinach plants' nitrate accumulation has been

discovered in the inorganic with organic combination fertilizers compared to the inorganic fertilizers, lower than WHO standards. Rani et al. (2013) have found that applying farmyard manure and chemical fertilizers substantially increases growth in the spinach and other leafy vegetable types. Phosphorus and nitrogen remained in study soils have been raised by increasing applied organic nitrogen.

Alga 600 is a botanical fertilizer extracted from Sargassum marine plants, rich in Alganic acid and cytokinins, as well as from the seaweed laminaria (containing Mg 0.42-0.6%, Ca 0.4-1.6%, K_2O 18-22%, Fe 0.15-0.3%, S 1.5-2.5%, Cu 20-45 mg/L, I 300-600 ppm, and Na 2.20-3.20%). Also, 10-30% of Alginic acid is a 100% water-soluble extract (Clerpka 2004). Combinations of the inorganic and organic fertilizers to the soils had greater effects upon the increase of the yield and the enhancement of the fertility of the soil (Clerpka 2004). Jakhro et al. (2017) showed that the plantation of the spinach that has been nourished with 75kg N + 6t ha-1 FYM had resulted in the production of plant height, fresh weight, leaves per plant, leaf length, t ha-1 spinach yield, and yield of the spinach in each one of the plots. The crop that has been fertilized by 75kg N + 4t ha-1 FYM had resulted in the production of the optimal plant height, leaves per plant, length of the leaf, fresh weight, t ha-1 spinach yield, kg spinach yield in each one of the plots. In contrast, reducing the N, FYM or N application with no FYM had shown negative impacts upon the spinach yields. The application of nitrogen from the urea has been the most effective than the other nitrogen sources on spinach growth and yield characters (Shormin & Kibria 2018). Rop et al. (2012) reported that increasing N fertilizer increased some vegetative yield and growth of the Indian spinach. Information on the yield and growth of the Indian spinach as affected by nitrogen from different inorganic sources is scarce. Therefore, this study was performed to study the impacts of nitrogen and organic fertilization on the growth and yield of the spinach**,** using two levels of N (Urea) (0 and 40kg/donum) and organic fertilizer Alga 600 at (0, 2, 4, and 6g/L.).

Materials and Methods

This work was conducted in the vegetable field of Horticulture and Landscaping Department of Agriculture and Forestry College, the University of Mosul, during the planting season of fall 2019/2020, to study the effects of organic and nitrogen fertilization on the growth and yield of spinach, as the seeds of the spinach c.v. (PCRA), obtained from Samag seeds PVT Company. Ltd, India. The land was sowed on 7/10/2019, on the panels (area of one panel was 1x0.45m) with three lines for each panel, which represents one experimental unit, where different concentrations of organic fertilizer Alga600 viz. 0, 2, 4, and6g/L were used, with two levels of nitrogen fertilizer (urea) as 0 and 40kg/donum. Thus, we have 8 experimental units, with three replications for each experimental unit, organized by designing a randomized complete block design (RCBD) Factorial experiment. All agricultural service operations have been conducted in productive fields in the research area (Matloub et al. 1989). The following data have been recorded: length of the leaf (cm), number of leaves for each one of the plants, fresh weight of whole plant (g), total chlorophyll content in Leaves by SPAD method, number of flower spikes (inflorescences) for each plant, length of flower spike (inflorescences) (cm) total yield (ton/ha), weight of seeds/experimental unit (gm), the weight of the seeds in every one of the plants (g), and weight of 100 seeds (g). The data were analyzed using SAS (SAS 2007) according to Dunk's polynomial test at a 5% probability level (Torrie & Steel 1980).

Results and Discussion

Effect of nitrogen fertilizer: Table 1 shows the effects of nitrogen fertilizer on the growth, yield, and flowering of spinach plants i.e. a significant impact observed on the traits of leaf length, chlorophyll content, fresh weight of the plant, total yield/ha., length of inflorescences, seeds weight /plot, seed

Table 1. Impacts of N fertilizer on growth, flowering, yield for spinach in growing season 2019/2020.

Nitrogen (kg/donum)	X 1	X2	X 3	X4	X5	X 6	X7	X8	X9	X 10
0	27.123[b]	23.294[a]	31.538[b]	16.381[b]	10145.4[b]	4.346[a]	112.331[b]	122.14[b]	59.693[a]	1.102[a]
40	29.833[a]	20.98[a]	37.891[a]	28.816[a]	59332.1[a]	4.011[a]	127.913[a]	153.593[a]	48.77b	1.04[a]

X1= length of the leaf (cm), x2=no. of leaves /plant, x3=chlorophyll, x4= weight of the plant (gm), x5=total yield (kg/ha.), x6=no. of inflorescences /plant, x7= inflorescences length (cm), x8=seeds weight /plot, x9=seeds weight/plant (g), x10=weight of 100 seeds.

weight in each one of the plants and weight of 100 seed. The fertilized treatments with N at 40kg/donm outperformed significantly over most of the traits except for the number of leaves in each one of the plants, the number of inflorescences /plant, and the weight of 100 seeds. An increase in the total fresh yield could be a result of the meristematic activity for the production of more organs and tissues because nitrogen has an important impact on the nucleic acids and protein syntheses and the formation of the protoplasm (Morchmer 1986), which could result in increasing the protoplasm proportion to the size of the cells (Russel 1973). This may result in a high yield because vegetative growth in the spinach has been considered one of the yield parameters.

The maximum yield and growth that have been induced by fertilization with N fertilizer confirmed the suitability of the fertilizer containing N for some of the crops such as the spinach; the short cycle of the crop still made these fertilizers available readily to the uptake of the plant more suitable to obtain higher yield levels (Li & Wang 2003). The height of a plant depends on plant vigor and growth habit; it is a vigorously growing plant, and nitrogen significantly affects the length of vines. The positive role of nitrogen in enhancing plant height has been reported by some researchers (Ninfali & Bacchiocca, 2004; Abdel-kader et al., 2007; Stagnari et al. 2007; Novaes et al. 2009; Rop 2012; Bharad et al. 2013; Wahocho et al. 2016 Jakhro et al. 2017: Shormin 2018), that N fertilizer increase the vegetative growth, chlorophyll content, high biomass, high total fresh yield, seeds yield per plant and per unit area in the spinach plant.

Effect of Alga 600: Table 2 shows the effect of Alga600 at 0, 2, 4, and 6 g/l on the characteristics of vegetative growth, yield, and seeds in spinach, indicating that the 6g/l of Alga was significantly higher in most traits except the number of spikes for each one of the plants and the weight of 100 seeds. Alga 600 at 6g/l has been found to produce the highest value of the leaf length (31.887cm). This level was significantly higher than the levels of 0, 2, and 4g/l, and between these levels did not find any significant difference in this trait. As for the number of leaves for each plant, 6g/l of Alga 600 outperformed the rest of the levels for this trait and gave the highest value (25.047), while in the control group, the lowest value was 21.297. There are also significant differences between levels 0 and 2gl compared with 4g/l. Alga 600 at 6g/l significantly affected the chlorophyll content compared with other treatments. There was a significant impact of 6g/l of Alga 600 on the length of the plant, which was 25.368cm, and it differed significantly with the three groups.

The total yield kg/ha increased significantly in 6g/l of Alga 600 (50041.25 kg), which differed significantly from other levels. There were no significant differences between 2 and 4g/l on this trait. Alga 600 did not affect the number of spikes (inflorescences). For the spike (inflorescences) length, the effect of the 6g/l was higher than 0, 2, 4g/l treatments. Also, there were significant effects of 6g/l on the weight of the seeds /plot (166.11g). The results also indicated a significant effect of 0, 2, 4, and 6g/l of Alga 600 on the weight of the seed for each plant which its value at 6g/l was 67.2g (Table 2).

For the weight of 100 seeds, a significant impact was observed in all levels of Alga 600, e.g. the level of 4g/l produced the highest value (1.155g). These results showed the effects of the organic fertilizer Alga 660 to increase in properties of the vegetative growth, flowering, seed production, and yield because the organic fertilizer contains many mineral

Table 2. Effect of Alga 600 on growth, flowering, yield for spinach plant in growing season 2019/2020*.

Alga 600 (gm/L.)	X1	X 2	X3	X 4	X5	X 6	X7	X8	X9	X10
0	24.777^{c}	21.297^{b}	33.24^{b}	22.19^{b}	29738.95^{c}	3.890^{a}	112.442c	117.65^{d}	47. 02^{c}	0.974^{a}
2	28.79^{b}	20.692^{b}	34.808^{b}	20.579^{c}	30126.45^{b}	3.814^{a}	115.61^{c}	121.905^{c}	47.825^{c}	1.087^{a}
4	28.459^{b}	19.84^{c}	34.017^{b}	22.256^{b}	33981.85^{b}	4.0505^{a}	120.607^{b}	145.80^{b}	54.88^{b}	1.155^{a}
6	31.887^{a}	25.047^{a}	36.792^{a}	25.368^{a}	50041.25^{a}	4.506^{a}	131.83^{a}	166. 11^{a}	67.2^{a}	1.069^{a}

X1= length of the leaf (cm), x2=no. of leaves /plant, x3=chlorophyll, x4= weight of the plant (gm), x5=total yield (kg/ha.), x6=no. of inflorescences/plant, x7= inflorescences length (cm), x8=seed weight /plot, x9=seeds weight/plant (g), x10=weight of 100 seeds

nutrients, amino acids, and growth regulators that stimulate root growth and vegetative growth, improve yield characteristics in many vegetable crops, increase resistance to insects and their tolerance to freezing, drought and water stress conditions, and to stimulate cell division. The cells of the plant tissues and their elongation lead to balance in the biological and physiological processes within the plant's tissues (Verkleij 1992; Thomas & Li 2004). Verkleij (1992) and Jakhro et al. (2017) indicated that a marine extract sprayed on the foliage causes a significant increase in leaf length, total yield per unit area, and seeds yield per plant in spinach plant. Also, the same result was reported in other works (Anyaegbu et al. 2010; Shah et al. 2016; Hove et al. 2020; Rioba et al. 2020) on vegetative growth and yield in swiss chard affected by organic fertilizer.

Effect of interaction between nitrogen fertilizer and Alga 600: Table 3 shows the effects of the interaction between the levels of nitrogen fertilization and Alga 600 organic fertilizer on the growth, flowering, and yield of spinach plants. There were no significant differences between interaction treatments of 40kg of nitrogen per acre with 4 and 6g/l of Alga 600. Between the 0 nitrogen and 6g/l of Alga 600 and the minimum length resulted in the interaction treatment of 0kg of nitrogen and 0g of Alga 600. Concerning effects of binary interactions between the two factors on the number of leaves for each plant, the treatment of the binary interaction 40kg of nitrogen with 6g/l of Alga600 had the highest number (24,303) significantly different from the interaction between 0kg of nitrogen and levels of 0, 2 and 4g of Alga 600. The lowest number was recorded in the interaction treatment of 0kg of nitrogen fertilizer and 0g of Alga 600 (22,083). The interaction between the 40kg of nitrogen with the Alga 600 of 0, 2, 4, and 6g/l resulted in the highest total chlorophyll content, and the highest one observed in 40kg of nitrogen + 6g of Alga 600 (40.350), and the lowest one found in the control group (29.307).

The interaction between 40kg of nitrogen and 6g of Alga 600 produced the highest weight in the plant, as 30.163g, and the lowest weight in 0 kg of the nitrogen fertilizer and 0g of Alga 600 (16,443g). The effects of the interaction of the two factors were inconsistent with the total yield ton/ha, and the dual interaction treatment produced between 40kg of nitrogen fertilizer and 6g of Alga 600 (80,556tons/ha). For the number of the flowering inflorescences, no effect was found in the binary interaction between the nitrogen fertilizer and Alga 600 (Table 3). The results indicate that the length of the flower spike (inflorescences) has been significantly affected by the interaction of nitrogen fertilizer 40kg and 6g of Alga600 (138.44cm) significantly different from other treatments. Also, the dual interaction between 40kg of nitrogen fertilizer and 6g of Alga 600 had the highest weight of seeds (187.73g). The lowest weight resulted from the interactions between 0kg nitrogen with 0g Alga 600 (96.99g). For the seed weight for each plant, the treatment of the interaction between 0kg of nitrogen fertilizer and 4 and 6g of Alga 600 produced the highest value as 66.61 and 77.26g, respectively. The

Table 3. Effects of interactions between N. fertilizer and Alga 600 on growth, flowering, yield for spinach plant in growing season 2019/2020*.

N. fertilizer (Kg/donum)	Alga 600 (g/L.)	X 1	X2	X3	X 4	X5	X 6	X7	X8	X 9	X 10
0	1	24.193^{c}	22.083^{b}	29.307^{c}	16.443^{d}	8551.5^{f}	4.388^{a}	99.553c	96.99^{d}	45.17c	0.977^{a}
	2	27.720^{b}	22.777^{b}	32.953^{b}	14.257^{c}	10963.3^{d}	4.319^{a}	108.11^{bc}	103.44^{c}	49.73^{bc}	1.037^{a}
	3	25.667^{c}	22.527^{b}	30.660^{bc}	14.250^{c}	11407.7^{e}	4.011^{a}	116.44^{b}	143.64^{ab}	66.61^{a}	1.257^{a}
	4	30.913^{a}	25.790^{a}	33.233^{bc}	20.573^{b}	19526.1^{d}	4.667^{a}	125.22^{a}	144.49^{b}	77.2^{a}	1.13a
40	1	25.360^{c}	20.330^{ab}	37.177^{ab}	27.940^{b}	50926.4^{bc}	3.391^{a}	125.33^{a}	138.31^{b}	48.87^{bc}	0.970^{a}
	2	29.860^{b}	18.607^{ab}	36.663^{ab}	26.900^{b}	49289.6^{c}	3.308^{a}	123.11^{b}	140.37^{b}	45.92^{bc}	1.137^{a}
	3	31.250^{ab}	17.153^{b}	37.373^{ab}	30.262^{a}	56556.0^{b}	5.00^{a}	124.77^{a}	147.96b	43.15^{c}	1.053^{a}
	4	32.860^{a}	24.303^{a}	40.350^{a}	30.163^{a}	80556.0^{a}	4.345^{a}	138.44^{a}	187.73^{a}	57.14^{b}	1.00^{a}

X1= length of the leaf (cm), x2=no. of the leaves /plant, x3=chlorophyll, x4= weight of the plant (gm), x5=total yield (kg/ha.), x6=no. of inflorescences /plant, x7= inflorescences length (cm), x8=seed weight /plot, x9=seeds weight/plant (g), x10=weight of 100 seeds.

weight of 100 g of seeds has been considerably affected by interactions of nitrogen fertilizer and the Alga 600. The interaction between 0kg nitrogen and 4g of Alga 600 (1.257g) is significantly different from 40 kg nitrogen and Alga 600 organic fertilizer levels.

Acknowledgment

The authors would like to thank the Univ. of Mosul / Agriculture and Forestry College for providing facilities and, thanks to M M Salih, at the Univ. of Telafar for data analysis.

References

Mahmoud, E.; Abd El-Kader, N.; Elbaroudy, A. & Abdel Rahman, L. 2007. Residual effects of different organic and inorganic fertilizers on spinach (*Spinacia oleracea* L.) plant grown on clay and sandy soils. Alexandria Journal of Agricultural Research-Alexandria University 6(3): 49.

Anyaegbu, P.O.; Iwuanyanwu, U.P. & Ekwughe, E.U. 2010. Nutrient uptake and root yield of cassava as influenced by liming and poultry manure under different cropping system. International Journal of Science and Research 2: 82-89.

Bergquist, S.Å.; Gertsson, U.E.; Knuthsen, P. & Olsson, M.E. 2005. Flavonoids in baby spinach (*Spinacia oleracea* L.): changes during plant growth and storage. Journal of Agricultural and Food Chemistry 53(24): 9459-9464.

Bharad S.G.; Korde, S.D.; Pravina, S. & Baviskar, M.N. 2013. Effect of organic manures and number of cuttings on growth, yield and quality of Indian spinach. Asian Journal of Horticulture 8(1): 60-64.

Conte, A.; Conversa, G.; Scrocco, C.; Brescia, I.; Laverse, J.; Elia, A. & Del Nobile, M.A. 2008. Influence of growing periods on the quality of baby spinach leaves at harvest and during storage as minimally processed produce. Postharvest Biology and Technology 50(2-3): 190-196.

Forman, D. & Altman, D. 2004. Vitamins to prevent cancer: supplementary problems. The Lancet 364(9441): 1193-1194.

Gastal, F. & Lemaire G. 2002. N uptake and distribution in crops: an agronomical and ecophysiological perspective. Journal of Experimental Botany 53(370): 789-799.

Hassan, A.A.M. 2003. Production of cabbage and Chenopodiaceae vegetables, production technology and advanced agricultural practices, Dar Al-Arabiya for Publishing and Distribution, Nasr City, Arab Republic of Egypt. 325 p.

Hove, K.; Johannes, J.; Hatutale, G.; Awala, S.K. & Ausiku, P. 2020. Magna Scientia Advanced Biology and Pharmacy.

Jakhro, M.I.; Shah, S.I.; Amanullah, Z.M.; Rahujo, Z.A.; Ahmed, S. & Jakhro, M.A. 2017. Growth and yield of spinach (*Spinacia oleracia*) under fluctuating levels of organic and inorganic fertilizers. International Journal of Development Research 7: 11454-11460.

Clerpka, T. 2004.*Affiliation with foam*. September 13, 2004 in Seattle, USA.

Koivu, T.; Pironen, V. & Mattila, P. 1999. *Vegetable as Sources of Vitamin K in Finland*, In: M. Hagg, R. Anvenainen, A.M. Evers, K. Tillikkala, (eds.). Agri-food quality 11: quality management of fruits and vegetable –from field to table. Royal Society of Chemistry. pp: 300-302.

Lateef, M. A., Noori, A. M., Saleh, Y. M., & Al-Taey, D. K. (2021). The effect of foliar spraying with salicylic acid and calcium chloride on the growth, yield, and storage traits of two strawberry cultivars, fragaria x ananassa duch. International Journal of Agricultural and Statistical Sciences 17(2): 611-615.

Lee, S.K. & Kader, A.A. 2000. Pre-harvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biology and Technology 20: 207-220.

Mohammed, M.M. & Al-Ubaidy, R.M. 2020. Influence of yeast and intercropping system on growth and yield traits of pea. International Journal of Agricultural and Statistical Sciences 16(1): 1577-1580.

Mahmoud, E.; Abd El-Kader, N.; Elbaroudy, A., & Abdel Rahman, L. 2007. Residual effects of different organic and inorganic fertilizers on spinach (*Spinacia oleracea* L.) plant grown on clay and sandy soils. Alexandria Journal of Agricultural Research-Alexandria University 6(3): 49.

Ninfali, P. & Bacchiocca, M. 2004. Parameters for the detention of post-harvest quality in fresh or transformed horticultural crops. Food Agriculture and Environment 2: 122-127.

Novaes, E.; Osorio, L.; Drost, D.R.; Miles, B.L.; Boaventura-Novaes, C.R.; Benedict, C.; Dervinis, C.; Yu, Q.; Sykes, R. & Davis, M. 2009. Quantitative genetic analysis of biomass and wood chemistry of populous under different nitrogen levels. New Phytology 182: 878-890.

Rani, A.A.; Abd El-Baky, M.M.H.; Abd El-Al, F.S. & Shaheen, A.M. 2013. The productivity of Jew's mallow plant as influenced by different NPK fertilization. Mansoura University Journal of Agricultural Sciences 29(10): 5773-5783.

Rioba, N.B.; Opala, P.A.; Bore, J.K.; Ochanda, S.O. & Sitienei, K. 2020. Effects of Vermicompost, Tithonia Green Manure and Urea on Quality of Swiss Chard (*Beta Vulgaris* L. *Var. Cicla* L.) in Kenya. Sustainable Agriculture Research 9(526-2021-468): 55-66.

Rop, N.K. 2012. TM Mutui and EK Kiprop, Influence of nitrogen fertilizer on the growth, yield and quality of Indian spinach (*Basella alba* L.), African Journal of Horticultural Science 6: 111-117.

Russel, E.W. 1973. *Soil Conditions and Plant Growth*. 10th Ed. London.

Ryder, E.J. 1979. Leafy salad vegetable. AVI Publishing Company, Inc., Westport, Conn. 66 p.

SAS. 2007. Statistical Analysis Systems SAS/STAT user's guide Version 9.1 Cary NC. SAS Institute Inc. USA

Shah, S.T.; Ghafoor, F.; Khan, N.; Sajid, M.; Ul Amin, N.; Shah, Z.; Bibi, S.; Ahmad, T. & ul Haq, F. 2016. Organic fertilizers affect the growth attributes of weeds and swiss chard. Pakistan Journal of Weed Science Research 22(3): 463-470

Shormin, T. & Kibria, M.G. 2018. Effects of Nitrogen from Different Inorganic Fertilizers on Growth and Yield of Indian Spinach (*Basella alba* L.). IOSR Journal of Pharmacy and Biological Sciences 13(5): 43-48.

Sisson, V.A.; Rufty, T.W. & Williamson, R.E. 1991. Nitrogen-use efficiency among flue-cured tobacco genotypes. Crop Science 31: 1615-1620.

Stagnari, F.; Di Bitetto, V. & Pisante, M. 2007. Effects of N fertilizers and rates on yield, safety and nutrients in processing spinach genotypes. Journal of Horticulture Science 114: 224-233.

Steel, R.G.D. & Torrie, J.H. 1980. *Principle and procedures of statistics*. M.G. Grow Hill book, Company Inc New York.

Li, T.S. 2002. Product development of sea buckthorn. Trends in New Crops and New Uses, 393-398.

Verkleij, F.N. 1992. Seaweed extracts in agriculture and horticulture Review. Biological Agriculture & Horticulture 8(4): 309-324.

Wahocho, N.A.; Memon, N.; Kandhro, M.N.; Miano, T.F.; Talpur, K.H. & Wahocho, S.A. 2016. Response of nitrogen on the growth and productivity of spinach (*Spinacia oleracea* L.), Sindh University Research Journal (Science Series) 48(2): 305-308

Wang, Z.; Zong, Z., Li, S. & Chen, B. 2002. Nitrate accumulation in vegetables and its residual in vegetable fields. Huanjing Kexue 23(3): 79-83.

Wang, Z.H. & Li, S.X. 2003. Effects of N forms and rates on vegetable growth and nitrate accumulation. Pedosphere 13(4): 309-316.

Watt, B.K. & Merrill, A.L. 1963. Composition of food. U.S. Department of Agriculture. Agriculture Handbook 8: 190.