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Response of nitrogen on the growth and productivity of spinach (*Spinacia oleracea* L.)

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Abstract: Nitrogen is one of the most critical nutrients for plant growth and development. Hence its optimum use in crop cultivation is a prerequisite for sustainability of Agriculture. A field trial was conducted during the growing season of 2014-15 to evaluate the response of nitrogen (N) on the growth and productivity of spinach. The study was designed according to randomized complete block design with three replicates. Five N doses viz; 0, 35, 70, 105 and 140 kg ha^{-1} were applied to evaluate the growth and yield parameters of spinach. The results revealed that various N levels had significant ($P<0.05$) effects on all the growth and yield contributing traits of spinach. The crop treated with the highest N level of 140 kg ha^{-1} showed positive effects on all the investigated parameters. In contrast, there was a significant reduction in all the growth and yield related attributes in control plants, where N was not applied. The crop fertilized with highest N level (140 kg ha^{-1}) showed maximum plant height (26.50 cm), took less days for the first cutting of the crop (21.633), produced increased number of leaves $plant^{-1}$ (17.167), and leaf length (23.767 cm), highest fresh weight of leaves (25.550 g), and maximum yield $plot^{-1}$ (11.700 kg) and yield ha^{-1} (9777.8 kg). However, a non-significant difference ($P>0.05$) was observed between N levels 140 kg ha^{-1} and 105 kg ha^{-1} for all the investigated growth and yield related parameters. Hence, 105 kg ha^{-1} was considered an optimum level for better growth and production of spinach.

Key words: Nitrogen, growth, productivity, spinach (*Spinacia oleracea* L.)

1. INTRODUCTION

Spinach (*Spinacia oleracea* L.) is highly nutritious green leafy vegetable crop of the family Chenopodiaceae. It is believed that spinach originated from Central and South West Asia (Baloch, 1994). It is a popular annual winter vegetable crop that can tolerate extreme cold stress (Toledo *et al.,* 2003). Spinach is normally grown for its delicious and tender green leaves. The leaves of spinach normally attain a height of about 2-30 cm having a width of about 1-15 cm (Watson, 2007). Spinach contains various vitamins, including vitamin C, E, and K and is also a good source of beta carotene. Spinach is an excellent source of iron and various other minerals, including potassium, sulfur, sodium, folic acid and oxalic acid (USDA, 2005).

Spinach generally grows best in cool and moist climate. The low temperature coupled with more humidity encourages the development of succulent and tender leaves (Khushk and Abro, 2006). The spinach usually takes three to four weeks from sowing to first cutting. The first cutting is generally performed when the plant produces five to six true leaves (Khushk and Abro, 2006).

In Pakistan, during 2011-12, the total cropped area of spinach was 8540 hectares with a production of about 107964 tonnes. During the same years, in Sindh province, spinach was grown on an area of 1561 hectares with a total production of about 7882 (GOP, 2013). Available evidences showed that production of spinach in Sindh province decreased significantly during the last couple of years (GOP, 2013). The low production of spinach in Sindh, Pakistan might be due to the influence of several factors, including the less attention of the farmers on land preparation, sowing time, improper application of cultural practices including weeding, irrigation and non judicious use of chemical fertilizers especially N in spinach cultivation.

Nitrogen plays a significant role in enhancing the plant growth and productivity (Fageria and Baligar, 2005). It enhances the photosynthetic activity and stimulates the vegetative growth of plants. (Milford *et al.,* 2000) reported that N has a highly significant effect on plant foliage. In addition, N also plays an important role in plant root systems (Fageria and Moreira, 2010). It improves the growth and production of root hairs and lateral roots (Zolla *et al.,* 2010). The established root system captures the water and nutrients more efficiently (Fageria and Baligar, 2005) that eventually allows the plants to grow vigorously and produce longer and heavier leaves.

Deficiency of N in agricultural soils is a global issue. Hence the optimum use of the N in crop cultivation is a prerequisite for acceptable and better yield of crop plants. It is widely observed that N is usually applied to crop plants in large quantity beyond their requirement. Available evidences indicated that excessive use of the N in crop cultivation decreased the nitrogen use efficiency of crop plants and mediated severe environmental (Raun and Johnson, 1999).

Nitrogen is the most essential element for spinach growth and productivity. Several lines of evidences revealed that N significantly influenced the growth and productivity of spinach (Popat *et al.* 2009) (Canali *et al.* 2008) documented that N application at the rate of 120 kg ha^{-1} showed a better yield of spinach. Similarly, Darani *et al.* (2013) also described that the N levels of 75 to 150 kg ha^{-1} are optimum levels for the satisfactory yield of spinach.

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In Sindh, Pakistan, the knowledge on the optimum level of N for spinach cultivation is lacking. Spinach is a leafy vegetable crop; hence the judicious use of the N is a prerequisite because low or high dose of N adversely affects the spinach productivity. In addition, overuse of N poses health risks to human beings due to the large amount of nitrate accumulation in the spinach leaves which is potentially toxic substance (Stagnari, 2007). it is mandatory to investigate the optimum N level for better productivity of spinach.

In the light of above mentioned facts, the current study was designed to investigate the response of the N on the growth and foliage production of spinach.

2. MATERIALS AND METHODS

The field study was carried out to evaluate the influence of N on the growth and productivity of Spinach during the growing season of 2014-15. The trial was arranged in a Randomized Complete Block Design with three replications. In this study, the total plot area was kept 3x 4 meters (12 m^2). The land was well prepared before sowing. Three plowings were applied to the experimental area. After plowing, big clods were crushed and then leveling was done for proper distribution of irrigation water. The seeds of spinach variety Sindhi palak were sown in the month of November, 2014. Sowing was done on ridges and three weeks later, the thinning was performed and the distance of about 30 cm and 5 cm was maintained between rows and plants, respectively. The five N levels, including a control (0-35-70-105 and 140 kg ha^{-1}) were evaluated with a constant dose of phosphorous (P) and potassium (K) at the rate of 60 and 50 kg, respectively. Urea was added in the soil as a source of nitrogen, while P and K were incorporated into the soil in the form of single superphosphate and sulfate of potash, respectively. Full dose of P and K were applied at the time of land preparation. However, N was applied in three split doses. The one third of N was incorporated into the soil at the time of sowing and remaining N was added in the soil at the time of first and second cuttings, respectively. In total, four cuttings were taken from the crop. The crop was irrigated at the interval of 15 days, and all the required cultured practices, including weeding and hoeing were performed throughout the growth period of the crop. No serious incidence of insect pest and disease outbreaks were observed in crop during the whole study. The crop was harvested manually and data were collected plant characteristics, including plant height (cm), days taken for first cutting, number of leaves $plant^{-1}$, length of leaves (cm), fresh weight of leaves $plant^{-1}$(g), yield pot^{-1} and yield ha^{-1}.

Statistical Analysis

The statistical analysis of the collected data was performed by analysis of variance (ANOVA). The treatments means were separated and compared by least significant difference (LSD) at the 5% probability level using the statistix 8.1 software (Statistix, 2006).

3. RESULTS AND DISCUSSION

Response of N on the growth characteristics of spinach

All the growth characteristics of spinach were significantly influenced by various nitrogen (N) levels. The results indicated that plants treated with the highest N level of 140 Kg ha^{-1} showed better growth performance in terms of plant height, number of leaves and length of leaves as compared to control **(Table 1).** The maximum plant height (26.50 cm) was observed from the fertilized plants where N was applied at the rate of 140 Kg ha^{-1}. These results are at par with the results (26.27 cm) obtained from the plants where N was applied at 105 kg ha^{-1}. The minimum plant height (8.133 cm) was observed in control plots where N was not applied. The highest plant height at increasing N level might be due to the effective role of N in cell division and protein synthesis, therefore the height of the plants increased significantly (Firoz, 2009). The positive role of N in enhancing plant height is also reported by Canali *et al.* (2008) who reported that application of N at 120 kg ha^{-1} increased plant height and other growth characters significantly. These results are further supported by the findings of other authors, including Ajmal *et al*. (2013) and Sajid *et al*. (2012) on okra crop. They also reported maximum height of plants at increasing N levels.

Table-1. Effect of applied N on the growth characteristics of Spinach

Treatment N (kg ha^{-1})	Plant Height (cm)	Days taken to first cutting	Number of leaves $plant^{-1}$	Length of leaves plant-1 (cm)
0 (Control)	8.133 d	30.133 a	6.200 d	8.233 d
35 kg ha^{-1}	14.200 c	28.300 b	9.400 c	12.533 c
70 kg ha^{-1}	20.400 b	25.400 c	13.500 b	17.667 b
105 kg ha^{-1}	26.267 a	22.067 d	16.900 a	23.533 a
140 kg ha^{-1}	26.500 a	21.633 d	17.167 a	23.767 a
SE±	0.1346	0.2803	0.5204	0.2696
LSD 0.05	0.3103	0.6463	1.2000	0.6216
CV%	0.86	1.35	5.04	1.93

Values followed by similar letters are not significantly different at 0.05 probability level

Table-2 Effect of applied N on the yield characteristics of Spinach

Treatment N (kg ha^{-1})	Fresh weight of leaves $plant^{-1}$(g)	Yield $plot^{1}$ (kg)	Yield ha^{-1} (kg)
0 (Control)	13.167 d	4.067 d	3388.9 d
35 kg ha^{-1}	16.400 c	6.267 c	5222.2 c
70 kg ha^{-1}	20.333 b	9.300 b	7750.0 b
105 kg ha^{-1}	25.433 a	11.500 a	9583.3 a
140 kg ha^{-1}	25.550 a	11.700 a	9777.8 a
SE±	0.0637	0.1140	99.380
LSD 0.05	0.1469	0.2629	229.17
CV%	0.39	1.63	1.70

Values followed by similar letters are not significantly different at 0.05 probability level

The days taken to first cutting ranged from 21.633 to 30.133. Plants fertilized with increasing N level (140 Kg ha^{-1}) took (21.633) days closely followed by (22.067) days where N was applied @ 105 kg ha^{-1}. The maximum days (30.133) to first cutting were observed from the plants where N was not applied. The less time for first cutting might be due to the application of N in sufficient quantity that enhanced the fertility status of the soil; eventually crop took less time for first cuttings. On the contrary, low application of N might have adversely affected the growth of plants; resultantly the crop took maximum days for first cutting.

The number of leaves and length of leaves responded significantly to various N levels. The results reflected that maximum number of leaves (17.167) $plant^{-1}$ was noted in plants received highest N level (140 kg ha^{-1}) closely followed by 105 kg ha^{-1} with leaves (16.900) $plant^{-1}$. However, both these N levels revealed a non- significant ($P>0.05$) difference. A significant reduction in leaves number (13.500) and (9.400) was observed when the crop was treated with N levels with 70 and 35 kg ha^{-1}, respectively. The lowest number of leaves (6.200) was recorded in case of control when N was not applied to the plants. These results reflected the essential and significant role of N in achieving maximum leaves in plants. Similarly, maximum length of leaves (23.767 cm) was noted in plants treated with 140 kg N ha^{-1}). These results are statistically similar with the results (23.533 cm) obtained from plants where N was applied at 105 kg ha^{-1}. Minimum length of leaves (8.233 cm) was noted in control plants that were treated with (0 Kg N ha^{-1}). The leaves number and length of leaves are very important traits that highly affect the total yield of any leafy vegetable. In the present study, the application of N in adequate quantity encouraged the vigorous and healthy growth of plants, subsequently more leaves with a maximum length sprouted in plants. These results are strongly supported by Darani *et al.* (2013), who reported the maximum number of leaves and length of leaves at increasing N levels from 75-150 kg ha^{-1}. These results are also in agreements with the findings of Popat *et al.* (2009) and Liphadzi et al. (2006). They also reported that the number of leaves and leaf length increased significantly when N was applied to spinach in optimum quantity.

Response of N on the yield characteristics of spinach

The yield related attributes were significantly affected by various N levels. The trend of increased yield from 13.167 g to 25.550 g was observed with the increasing levels of N. The fresh weight (25.550 g) of leaves was observed from the plants where N was applied at 140 kg ha^{-1} followed by the results (25.433 g) at 105 kg N ha^{-1}. Fresh weight of leaves was significantly decreased to 20.333 g and 16.400 g when the crop was treated with N levels of 70 kg ha^{-1} and 35 kg ha^{-1}, respectively. The minimum weight of leaves (13.167 g) was recorded when N was not added to the soil. These results suggest that application of N at optimum levels is perquisite for healthy growth of plants; resultantly the fresh weight of leaves was significantly increased. The highly significant response of N on leaf growth and development is also supported by Dua *et al.* (2010) and Sajrani *et al.* (2012). The results of fresh weight of leaves are further confirmed by the findings of other studies on radish and turnip crops (El-Desuki, 2005, Salardini *et al.,* 2009). These authors also reported that that fresh weight of leaves increased with higher N levels.

In the present study, various N levels also had a significant effect on plot yield and yield ha^{-1}. For yield $plot^{-1}$ and yield ha^{-1}, the highest N level of 140 kg showed a maximum value (11.700 kg) and (9777.8 kg), respectively. The results further reflected that plot yield and yield kg ha^{-1} of spinach was subsequently reduced to 9.300 kg $plot^{-1}$ and 7750.0 kg ha^{-1}, when the N level was decreased to 70 kg ha^{-1}. Plants which were not treated with N showed a highly adverse effect on yield and produced lowest values for yield $plot^{-1}$ (4.067 kg) and yield ha^{-1} (3388.9 kg), respectively. The yield of spinach depends upon several plant attributes including plant height, leaf number, length and weight of leaves. The application of N in adequate quantity might have promoted the growth and development of plants. The vigorous plant growth significantly enhanced plant height, number of leaves and weight of leaves, ultimately contributed to the increase in yield. These results are in agreement with the findings of Biemond (1996), Liphadzi *et al*. (2006), and Popat *et al.* (2009). These authors also reported that higher N levels increased the yield and productivity of spinach.

4. CONCLUSION AND RECOMMENDATIONS

On the basis of the results of the present study, it is concluded that although plants fertilized with increasing N level of 140 kg ha^{-1} showed greatest values for all the evaluated growth and yield traits. However, N levels of 140 kg ha^{-1} and 105 kg ha^{-1} exhibited a non- significant differences ($P<0.05$) for all assessed parameters. Hence, for getting higher yield, spinach may be fertilized with N at 105 kg ha^{-1}. However, further investigation needs to be carried out in a wide variety of soils and diverse environmental conditions for getting an optimum yield of spinach under low nitrogen conditions.

REFERENCES:

Ajmal, M. K., M. Sajid, Z. Hussain, A. Rab, M. B. Khan, W Fazal and B. Shahida. (2013) How nitrogen and phosphorus influence the phenology of okra**.** Pakistan Journal of Botany, 45 (2): 479-482.

Amjad, M., M. Sultan, A. Anjum, C. M. Ayyub, and M. Mushtaq. (2001) Comparative study on the performance

of some exotic okra cultivars. International Journal of Agriculture and Biology, 3(4):421 425.

Biemond, H.; H.Vos and P.C. Struik (1996). Effects of nitrogen on accumulation and partitioning of dry matter and nitrogen vegetable. 3. Spinach. Netherland Journal of Agricultural Science. 44: 227-229.

Bilekudari, M. K., V.K. Deshpande and M. Shekargouda. (2005) Effect of spacing and fertilizer levels on growth, seed yield and quality of radish. Karnataka Journal of Agricultural Science, 18 (2): 338-342.

Baloch, A. F. (1994) Vegetable Crops. In; M. N. Malik (Ed). Horticulture. National Book Foundation, Islamabad, 498 Pp. Pakistan.

Canali, S., F. Montemurro, F. Tittarelli and O. masetti. (2008) Effect of nitrogen fertilization reduction on yield, quality and N utilization of processing spinach. Journal of Food, Agriculture & Environment, 6 (3 and 4): 242-247.

Darani, F. H., H. Zeinali, A. H. S. Rad, A. Khourgami and H. Nasrollahi. (2013). Effect of planting date and nitrogen fertilizer on two varieties (inner and outer) of spinach. Annals of Biological Research, 4 (2): 56-59.

Dua, V. K., P. M. Govindakrishnan and S. S. Lal. (2010) Effect of FYM and N levels on spinach yield, N-use efficiency and soil fertility in potato-spinach sequence . Potato Journal, 37 (3/4). 151-156.

El-Desuki, M., S. R. Salman, M. A. El-Nemr and M. R. A. Maawgoud. (2005) Effect of plant density and nitrogen application on the growth, yield and quality of radish (*Raphanus sativus* L.). Journal of Agronomy, 4 (3): 225-229.

Fageria N. K. and V. C. Baligar. (2005) Enhancing nitrogen use efficiency in crop plants. Advances in Agronomy, 88: 97-185.

Fageria, N. K and A. Moreira. (2011) The role of mineral nutrition on root growth of crop plants. In Donald L. Sparks, editor: Advances in Agronomy, Burlington: Academic Press, Brazil, Vol. 110, 251-331.

Firoz, Z. A. (2009) Impact of nitrogen and phosphorus on the growth and yield of okra (*Abelmoschus esculentus* L. Moench) in hill slope condition. Bangladesh Jour. of Agricultural. Res. 34 (4): 713-722.

GOP, (2013) Fruits, vegetables and condiments statistics of Pakistan (2011-12). Ministry of national food security & research, Islamabad.

Khushk, A. M. and R. Abro. (2006) Venturing in spinach cultivation. Pakistan.com (PARC): browsed on 31st July, 2009.

Liphadzi, K. B., M.Maboko and J. Viljoen (2006) Spinach growth and yield response to reduced fertilizer application and irrigation. ASA-CSSA- SSSA. International Meetings, India. November, 12-16.

Milford, G. F. J., M. J. Armstrong, P. J. Jarvis, B. J. Houghton, D. M. Bellett-Travers, J. Jones, and R. A. leigh. (2000) Effects of potassium fertilizers on the yield, quality and potassium offtake of sugar beet crops grown on soils of different potassium status, Journal of Agricultural Science, 135: 1-10.

Popat, J. R., and V. K. Mahorkar. (2009) Effect of NPK through foliar application on growth and yield of Indian spinach. Annals of Plant Physiology, 23 (2): 201-203.

Raun W. R., and G. V. Johnson. (1999) Improving nitrogen use efficiency for cereal production. Agronomy Journal, 91:357–363.

Sajid., M, M. A. Khan, A. Rab, S. N. M. Shah, M. Arif, I. Jan, Z. Hussain and M. Mukhtiar. (2012) Impact of nitrogen and phosphorus on seed yield and yield components of okra cultivars. The Jour. of Animal and Plant Sciences, 22(3): 704-707.

Sajirani, E. B., M. J. Shakouri and S. Mafakheri. (2012) Response of Spinach (*Spinacia oleracea*) yield and nutrient uptake to urea and manure. Indian Journal of Science and Technology, 5 (1): 98-103.

Salardini, A. A., R. J. Eckard and D. R. Franks. (2009) Comparison of summer forages and the effect of nitrogen fertilizers on *Brassica* forages in Tasmania. Grass and Food Science, 13 (2): 65-72.

Stagnari, F., V . D. Bitetto and M. Pisante, (2007) Effect of N fertilizers and rates on yield, safety and nutrients in processing spinach genotypes. Scientia Horticulturae, 114: 225-233.

Statistix. B. (2006) Statistics 8 user guide, version Analytical software, P.O. Box 12185, Tallahassee 32317 USA. Copyright @ 2006 by Analytical software.

Toledo, M. E. A., Y. Ueda, Y. Imahori and M. Ayaki, (2003). L-ascorbic acid metabolism in spinach (*Spinacia oleracea* L.) during post harvest storage in light and dark. Post harvest biolo. Terminol., 28: 47-57.

USDA, (2005). USDA National Nutrient Database for Standard Reference, Release 18. Nutrient Data Laboratory. U.S. Department of Agriculture, Agricultural Research Service.
http://www.nal.usda.gov/fnic/foodcomp.

Watson, A. (2007) Agricultural Innovation in the early Islamic World. Cambridge University Press. United Kingdom, P. 62.

Zolla, G., Y. M. Heimer, S. Barak, (2010) Mild salinity stimulates a stress-induced morphogenic response in *Arabidopsis thaliana* roots. Journal of Experimental Botany, 61, 211–224.