Journal of Crop Nutrition Science
ISSN: 2423-7353 (Print) 2538-2470 (Online)
Vol. 5, No. 1, 2019
http://JCNS.iauahvaz.ac.ir
OPEN ACCESS

Impact of Zinc Sulfate and Nitrogen Fertilizer on Growth Curves and Crop Production of Green Beans (*Phaseolous vulgaris* L.)

Mehrnosh Kermanshahi*[1], Hasan Noriani[2]

1- Graduated of MSc, Department of Agronomy, Khuzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran.
2- Assistant Professor, Department of Agricultural Sciences, Payame Noor University, Tehran, Iran.

RESEARCH ARTICLE

ARTICLE INFO.
Received Date: *2 Jan. 2019*
Received in revised form: *5 Feb. 2019*
Accepted Date: *12 Mar. 2019*
Available online: *30 Mar. 2019*

To Cite This Article:
Mehrnosh Kermanshahi, Hasan Noriani. Impact of Zinc Sulfate and Nitrogen Fertilizer on Growth Curves and Crop Production of Green Beans (*Phaseolous vulgaris* L.). ***J. Crop. Nutr. Sci.,*** 5(1): 61-78, 2019.

ABSTRACT

BACKGROUND: Mineral nutrition is one of the most important factors affecting plant growth and productivity, also growth analysis is a way to assess what events occurs during plant growth.

OBJECTIVES: The goals of this study were to investigate the effect of different level of nitrogen fertilizer and zinc sulfate on growth indices of Green bean.

METHODS: Current research was conducted according split plot experiment based on randomized complete blocks design during summer of 2012 with three replications. The main plots consisted of four level of nitrogen form source of urea (N_1: 0, N_2: 30, N_3: 60, N_4: 90 kg.ha^{-1}) and four levels of zinc sulfate (Z_1: 0, Z_2: 10, Z_3: 20 and Z_4: 30 kg.ha^{-1}) belonged to sub plots.

RESULT: According result of growth analysis the highest amount of total dry matter (800 gr.m^{-2}), leaf area index (4.21), crop growth rate (27.35 gr.m^{-2}.day^{-1}), relative growth rate (0.037 gr.gr^{-1}.day^{-1}) and net assimilation rate (6.7 gr.m^{-2}.day^{-1}) was belonged to N_4 treatment and the lowest amount of treatments was for control.

CONCLUSION: Final result of current study revealed use of 90 kg.ha^{-1} nitrogen with consume zinc sulfate treatment led to achieve maximum level of growth indices in compare to another treatments and can advise to farmers in studied region.

KEYWORDS: *Dry matter, Nutrition, Pulse, Regression, Yield.*

***Corresponding Author:** Mehrnosh Kermanshahi ✉ mnh.kermanshahi@gmail.com

1. BACKGROUND

In many developing countries, protein rich foods, such as meat, milk, fish are still quite expensive; hence, many people still suffer from malnutrition. For this reason, most of food scientists are doing an effort that focusing on legumes to be developed as source of non-conventional protein (Adeniji and Ehiermere, 2003). Grain legumes are a major source of protein in human and animal nutrition and play a key role in crop rotations in most parts of the world. When grown in rotation with other crops, under certain environmental conditions, they can improve soil fertility and reduce the incidence of weeds, diseases and pests (Albayrak *et al*., 2006). Snap bean or 'French bean' (also referred to as green beans or string beans) is a strain of common bean, (*Phaseolus vulgaris* L), which is grown as a cash crop at large scale and smallholder farmers. So, snap bean is an important vegetable crop for local consumption and export (El-Awadi *et al*., 2011). Green bean is an important vegetable crop widely used as a protein source and for other nutrients in many developing countries. The total worldwide cultivated area of green beans is 1,527,613 hectares, producing 21,720,588 tons, as reported by FAO (2017). Among different commercial crops, green beans have the highest level of protein contents. There are favorable light and moisture conditions in Iran to plant such crops; sunny summers and cool nights as well as high-quality soil of Iran have prepared an ideal condition for planting and producing green beans, as the yield of this crop in Iran is 2.5 times more than the world average; in other words, the average yield of green beans in the world is 810 $kg.ha^{-1}$, while in Iran it is 1800 $kg.ha^{-1}$ (Ghasempour and Ashori, 2014). Mineral fertilizers application is essential for plant growth, development and productivity of snap bean plants. With fertilizers, farmers can produce more food and cash crops of better quality, especially in the low soil fertility which has been over-exploited. Nitrogen is one of the 17 chemical elements required for plant growth and reproduction. On the other hand, frequent or excessive amounts of nitrogen fertilizer would led to un-favorite effect on the growth and yield of snap bean plants and will lead to increase the losses of nitrogen fertilizer. So, the adequate amounts of nitrogen fertilization led to improve growth, yield and quality of pods (El-Awadi *et al*., 2011). The growth and yield of a crop can be adversely affected by deficient or excessive supply of any one of the essential nutrients. However, in intensive agriculture nitrogen is the major nutrient which determining crop yield. Nitrogen as an essential constituent of cell components having direct effect on growth, yield and quality of crop. Plant growth is affected more due to deficiency of nitrogen than that of any other nutrient. Nitrogen fertilization influences dry matter yield by influencing leaf area index, leaf area duration and photosynthetic efficiency (Mohan *et al*., 2015). Nitrogen (N) is essential for all biological process that occurs in the plant. A sub-optimal supply of N limits the expression of yield potentials of green bean varieties (Dauda *et al*., 2015). Nitrogen deficiency is frequently a major limiting factor for high yielding crops all over the world (Salvagiotti *et al*., 2008; Namvar *et al*., 2011a). The most important role of N in the plant is its presence in the structure of protein and nucleic acids which are the most important building and information substances of every cell. In addition, N is also found in chlorophyll that enables the plant to transfer energy from sunlight by photosynthesis. Thus, the supply of N to the plant will influence the amount of protein, amino acids, protoplasm and chlorophyll formed. Consequently, it influences cell size, leaf area and photosynthetic activity (Walley *et al*., 2005; Caliskan *et al*., 2008). Therefore, adequate supply of N is necessary to achieve high yield potential in crops. In general, N deficiency causes a reduction in growth rate, general chlorosis, often accompanied by early senescence of older leaves, and reduced yield (Erman *et al*., 2011). Mckenzie and Hill (1995) studied the effects of two levels of N applications (0 and 50 kg N ha^{-1}) on chickpea and reported that the increase of N rate from 0 to 50 kg N ha^{-1} significantly enhanced seed and dry matter yield, harvest index, number of pods per plant and 1000 seed weight. Nitrogen deficiency generally results in stunted growth and chlorotic leaves caused by poor assimilate formation that leads to premature flowering and shortening of the growth cycle (Lincoln and Edvardo, 2006). Limitation of nitrogen in any phase of the plant growth, causes reduction in yield (Mohammadian, 2002). Seventy years ago, zinc was recognized as an essential micronutrient (Sommer and Lipman, 1996), and its deficiency in agricultural crops is one of the most common micronutrient deficiencies (Gupta, 1989). Zinc is the second most abundant transition metal after iron and is involved in various biological processes in organisms (Sida-Arreola *et al*., 2017). Zinc (Zn) is an important transitional metal, and is the only metal present in all six classes of enzymes and act as component for several transcriptional factors (Prasad *et al*., 2012). Zn plays an important role in the synthesis of proteins and carbohydrates (Sajedi, *et al*., 2009). Zinc plays a significant role in various enzymatic and physiological activities in the plant system. It performs many catalytic function in the plant besides transformation of carbohydrates, chlorophyll and protein synthesis. Under conditions where there is a lack of zinc, a decrease of carbonic anhydrase enzyme can lead to a diminished rate of net photosynthesis. The use of zinc serves to increase the density of zinc and protein in seeds, pneumatic organs and the overall quality of seed production (Sharma *et al.*, 2014). Zinc deficient soils have been widely found in India, USA, Canada, New Zealand, Africa, Europe and South America (Pedersen, 1966). On the other hand, World Health Organization (WHO) reported that human population of developing countries faced with the deficiencies of zinc. Zn deficiency of human is the fifth major cause of diseases and deaths in these countries (WHO, 2002). Foliar fertilization has the advantage of low application rates, uniform distribution of fertilizer materials and quick responses to applied nutrients. Moreover, hidden hungers can easily be managed (Umer *et al*., 1999). Mahady (1990) found that foliar application of $ZnSO_4$ for faba bean plants increased number of pods/plant and seed yield. Thalooth *et al*. (2005) indicated that foliar spraying with Zn had a positive effect on yield and yield attributes of sunflower plants. Several research reports have established the essentiality and role of micronutrient-zinc on plant growth, development and yield (Grzebisz *et al*., 1999). Zinc is an essential micronutrient in biological systems, which is required in small quantities. It is involved in the formation and activation of enzymes that impact on the growth, development and production of plants (Poblaciones and Rengel, 2016). Its deficiency impacts on growth, pollen viability, flowering and grain production (Pandey *et al*., 2006). In humans, its deficiency is associated with problems of growth and learning capacity in children, and increases the risk of infections, cancer and DNA damage (Ahmed *et al*., 2014). It is present in around one third of the world population, which represents the fifth risk factor for diseases in developing countries (Shahzad *et al*., 2014). Today still its deficiency persists in our soils which creates problem in many physiological processes to function normally. A critical small concentration of zinc is required to perform several key pathways in plants. These pathways have important roles in growth regulation, photosynthesis and sugar formation, fertility and seed production, and defense against disease. These physiological functions will be impaired and the health and productivity of the plants will be adversely affected due to zinc deficiency. Thus resulting in lower yields (or even crop failure) and frequently in poorer quality crop products (Tahir *et al*., 2009). Zinc deficiency is a global nutritional constraint for plant growth, particularly in calcareous soils of arid and semi arid regions. One of the most important micronutrient deficiencies is attributed to zinc deficiency that is a worldwide problem in human nutrition. More than 2 billion people suffer from micronutrient deficiency including zinc deficiency. The major reasons for the widespread occurrence of Zn deficiency in humans, especially in developing countries is a high proportion of cereal-based foods in the human being daily diet. Zinc deficiency causes a number of health problems like impairment in linear growth, sexual maturation, learning ability, immune functions and the central nervous system. Selection and breeding of plant genotypes for higher resistance against Zn deficiency is a realistic and long-term solution to overcome Zn deficiency in soils. Breeding genotypes for resistance to Zn deficiency may, however, take considerable time. Therefore, Zn fertilization is still a widely used agronomic practice for farmers to correct Zn deficiency (Ranjbar and Bahmaniar, 2007). Nicolas *et al*. (2011) testing yield and nutritional quality of snap bean reported highest pod yield and pod number with the application of 200 kg N ha^{-1} compared to 100 and 0 kg N ha^{-1} and that pod length was not significantly affected. Begum *et al*. (2003) reported that highest fertilizer rate (90:50:120) produced the highest pod yield, pod length and pod weight. Cástor Omar Ponce *et al*. (2019) reported the doses best favoring an increase in biomass, production, and nitrogen assimilation in Green Beans were 50 ppm of $ZnSO_4$, 100 ppm of DTPA-Zn, and 25 ppm of zinc oxide nano fertilizers (NfsOZn). Mbeke *et al*. (2014) reported it can be recommended that 22 kg N ha would be economical for snap beans production. Srinivas and Naik observed that the pod yield of French bean increased with increasing rate of N application and they obtained 13.2 $t.ha^{-1}$ pod by using 160 kg N ha^{-1} (Srinivas and Naik, 1988). Guu *et al*. (1997) recorded 17.2 $t.ha^{-1}$ pod yield with fertilizer and manure application. Sena *et al*. (2010) reported that 150 kg nitrogen, 40 kg phosphorus along with a basal dose of 80 kg potassium, 10 kg sulphur and 5 t cow dung ha^{-1} are found economic for optimum yield of French bean. Negash *et al*. (2018) reported that application of 123 kg N ha^{-1} and 92 kg P_2O_5 ha^{-1} led produce the highest amount of seed yield. Physiological growth analysis is the important in prediction of yield. Growth analysis is a way to assess what events occurs during plant growth. Total dry matter trend (TDM), Crop growth rate (CGR) and relative growth rate are, the most important traits in plant growth analysis. Growth analysis is a way to assess what events occurs during plant growth. Total dry matter trend (TDM), Crop growth rate (CGR) and relative growth rate are, the most important traits in plant growth analysis. Growth analysis is a suitable method for plant response to different environmental conditions during plant life (Hokmalipour and Hamele Darbandi, 2011). Growth analysis is one way to verify the crops ecological adaptation to new environments, the competition between species, crops management effects and the identification of the productive capacity of different genotypes. The dynamics of dry matter distribution to various plant organs, their yielding and productivity may be characterized by using various indices of growth analysis (Zajac *et al*., 2005). Growth analysis is still the most simple and precise method to evaluate the contribution of different physiological processes in plant development. It provides a considerable insight into the functioning of a plant as depends on genotype or environment. The purpose of growth analysis is the determination of the increase in dry matter referred to a suitable basis for photosynthetically active tissue, LAI and amount of leaf protein (Ali *et al*., 2004; Gupta and Gupta, 2005; Alam and Haider, 2006). Kibe *et al*. (2006) in wheat and Yasari and Patwardhan (2006) in rapeseed concluded same results about growth indices. Namvar *et al*. (2011b) application of suitable amounts of nitrogen fertilizer (i. e. between 50 and 75 kg urea ha^{-1}) as a starter can be beneficial in improving growth indices, development and total yield of inoculated chickpea.

2. OBJECTIVES

The goals of this study were to investigate the effect of different level of nitrogen fertilizer and zinc sulfate on growth indices of Green bean.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

This research was conducted in Dezful to assessment growth curves and crop production of green beans affected different level of nitrogen fertilizer and zinc sulfate via split plot experiment based on randomized complete blocks design during summer of 2012 with three replications. The main plots consisted of four level of nitrogen form source of urea (0, 30, 60 and 90 $kg.ha^{-1}$) and four levels of zinc sulfate (0, 10, 20 and 30 $kg.ha^{-1}$) belonged to sub plots. Place of research was located in Ahvaz city at longitude 45°25'E and latitude 32°16'N in Khuzestan province (Southwest of Iran). The average annual rainfall, temperature, humidity and evaporation in the region is 386 mm, 24 C, 55% and 2800 mm, respectively. The averages of some meteorological parameters of the studied area were presented in table 1. The physical and chemical properties of studied field mentioned in table 2. The size of each plot was 6×4 m² and each block has 16 treatments. For the experiment, the distance between rows to rows was 50 cm with six rows per treatment.

Table 1. Mean of metrological information of experiment location at 2012

Month	July	August	September	October	November
Mean of Max. degree (C^0)	46.4	46.7	24.4	36.6	25.6
Mean of Min. degree (C^0)	25.8	27	22.9	18.8	13.6
Mean of Month degree (C^0)	36.1	36.9	32.7	27.7	19.6
Earth temperature (C^0)	24	25.1	20.5	23.3	12.6
Monthly Rainfall (mm)	0	0	0	0	82.2
Max. absolute relative humidity	48	49	57	72	83
Min. absolute relative humidity	9	12	13	12	37
Monthly sunny hours	290.6	317.8	32.7	268.5	170.6
Monthly average evaporation from evaporation pan	13.3	13.5	10.2	7.1	3.3

3.2. Farm Management

Amount of phosphate was computed and consumed on the basis of 50 kg phosphorous per hectare from triple super phosphate source, also Potassium consumed on the basis of 70 kg per hectare from sulfate potassium source. Mentioned fertilizer with Zinc sulfate treatments and 50% nitrogen fertilizer treatments were distributed in the field and mixed with soil by disk. Also 50% of the residual nitrogen fertilizer was applied at the beginning of flowering stage. During the growth period, all plots were weeded manually. No serious incidence of insect or disease was observed and no pesticide or fungicide was applied. Irrigation was done when needed depending on soil moisture.

Table 2. Physical and chemical properties of studied field

Depth of soil sampling (cm)	0-30
Depth of soil sampling (cm)	1.1
Electrical conductivity ($ds.m^{-1}$)	Silty loam
Soil texture	7
pH	0.49
Organic carbon (%)	0.23
Nitrogen ($mg.kg^{-1}$)	4.9
Phosphorus ($mg.kg^{-1}$)	105

3.3. Measured Traits

To quantitatively measure the plant growth and leaf area during the growing season from lines 2 and 6 of each plot, 3 plants were randomly selected after removing one margin meter from the top and bottom of each planting line (every two weeks). Then leaf area was determined by the weight method and after that the leaf area index was calculated in different experimental treatments. In order to measure the dry weight, samples were dried in oven device at 75-80°C for 48-72 hours in the laboratory. After ensuring that moisture was not reduced, the dry weight of the samples was determined with precise scales. After physiological ripening the final harvest area of each plot was 1 m^2. Crop growth rate (CGR), net assimilation rate (NAR) and the relative growth rate (RGR) was measured according fallowing formula (Redford, 1967):

Equ.1. CGR ($gr.m^{-2}.day^{-1}$) = TDM_2-TDM_1/T_2-T_1.

TDM_1= Primary dry weight (gr) TDM_2= Secondary dry weight (gr)

T_1= initial sampling time

T_2= Secondary sampling time

Equ.2. NAR ($gr.m^{-2}.day^{-1}$) = CGR × $LnLA_2$-$LnLA_1$/LA_2-LA_1.

LA_1 = Initial leaf area

LA_2 = Secondary leaf area

Equ.3. RGR ($gr.gr^{-1}.day^{-1}$) = [Ln (TDM_2) – Ln (TDM_1)]/T_2-T_1.

3.4. Statistical Analysis

Analysis of variance and mean comparisons were done by SAS (Ver.8), Minitab software (Ver.14) and Duncan multiple range test at 5% probability level.

4. RESULT AND DISCUSSION

4.1. Total Dry Matter (TDM)

Several equations were tested to study the trend of TDM changes over time. In the meantime, the equation whose coefficient of determination (R^2) was high for different treatments was identified as the best justification for plant dry matter changes during growth to maturity. Proper distribution of actual points around the curve and the rationality of displaying the trend of total dry weight changes physiologically indicated that this relationship was correct for all the treatments. The process of accumulation of dry matter at all levels in the formation and growth of dry matter in beans, like other crops, is sigmoid. After about 30 days, the dry matter accumulation in all treatments accelerated due to increased light absorption by the leaf surface and improved leaf photosynthetic efficiency. Over time and with increasing leaf area and greater radiation absorption, photosynthesis rates in the plant increased and the slope of the dry matter curve became more intense. At the end of the plant growth period, total dry matter decreased, due to the aging the plant and the decay of old and inferior bean leaves. The highest dry matter accumulation was obtained with application of 90 $kg.ha^{-1}$ nitrogen fertilizer treatment and nonuse of nitrogen fertilizer (control treatment) showed the lowest dry matter accumulation (Fig. 1). So nitrogen use therefore prolongs the growth stages. Due to increasing plant age, decrease in photosynthetic efficiency, leaf loss and net photosynthesis led to reduce the shoot dry matter content.

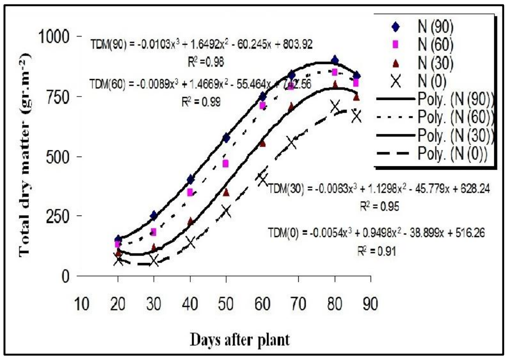

Fig. 1. Trend of regression variation of total dry matter affected different level of nitrogen.

It seems that increasing the amount of dry matter accumulation in different nitrogen treatments, due to higher vegetative growth, increased leaf photosynthetic efficiency due to increased chlorophyll content and later emergence of aging symptoms, thereby increasing plant photosynthetic capacity and dry weight production. The positive effect of nitrogen on dry matter accumulation in beans and other crops has been reported by Khavarinejad *et al.* (2011). It was improved by the application of sulfate on the dry matter accumulation process. As shown in Fig. 2, dry matter accumulation process it was improved by use of zinc sulfate.

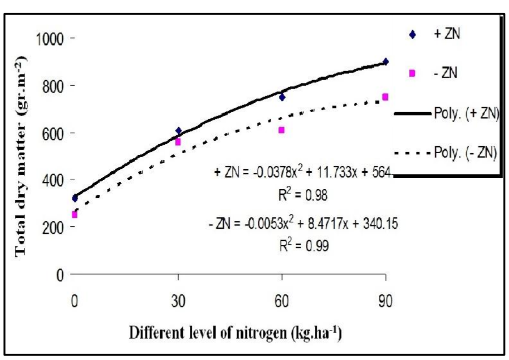

Fig. 2. Trend of regression variation of total dry matter affected different level of zinc sulfate

Zinc sulfate treatment had the highest dry matter, due to the increased leaf, stem and pod dry matter.

4.2. Leaf Area Index (*LAI*)

At the beginning of growth, the leaf area of the plant is made up by young leaves with high photosynthetic capacity, i.e., high efficiency of fixation of atmospheric CO_2. As the plant develops, leaf senescence enhances, reducing the photosynthetic efficiency of the leaves besides increasing respiratory losses, compromising the NAR and LAR, and consequently the RGR (Wilson, 1981). Leaf area index (LAI) is the main physiological determinant of crop yield. It describes the surface growth and light use during crop period (Ullah *et al.*, 2013). Heinemann *et al.* (2006) reported enhanced leaf area index by applying higher levels of nitrogen fertilizer. To better understand the relationship between radiation and photosynthesis and biomass production, leaf area index changes over time were investigated. The best fitting equation for predicting the trend of leaf area index changes over time is shown in Fig. 3. Increase in leaf area index due to different levels of nitrogen application was initially gradual and then had increasing trend due to development leaf area and canopy. Then LAI reached the maximum amount in flowering stage (about 60 days after planting). So nitrogen application led to increase LAI in 4.55. By increase nitrogen consumption more leaf area is created which, by absorbing more radiation, increases photosynthesis in the plant and eventually produces more dry matter.

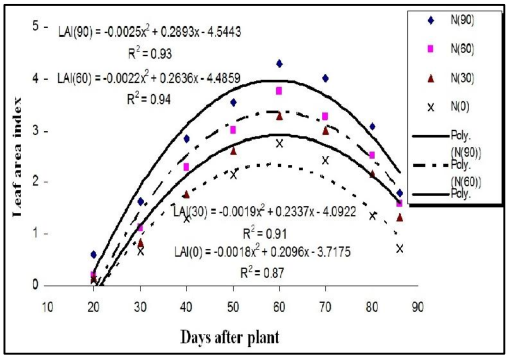

Fig. 3. Trend of regression variation of leaf area index affected different level of nitrogen.

The trend of changes in leaf area index for use zinc sulfate and control treatments under different levels of nitrogen is shown in Fig. 4. The trend of LAI changes shows that the pattern of leaf area index changes in both treatments is similar and follows a quadratic function. In this study, zinc sulfate treatment produced more LAI (4.21) at flowering stage than control treatment (nonuse zinc sulfate). The superiority of leaf area index in use zinc sulfate treatment was due to its greater leaf area than control treatment.

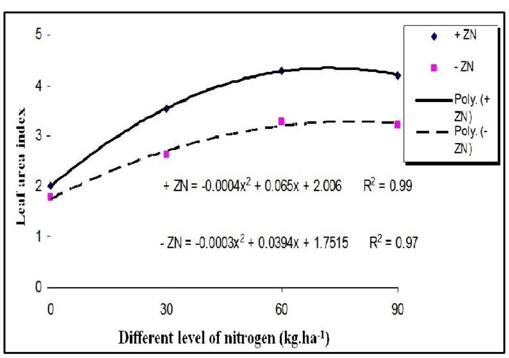

Fig. 4. Trend of regression variation of leaf area index affected different level of zinc sulfate

Hani *et al.* (2006) reported that plant height, stem diameters, LAI (leaf area index) increased significantly with increase in levels of nitrogen from 0 to 80 kg N ha^{-1}. However 40 and 80 kg N ha^{-1} remained at par with each other in fodder maize. While increasing nitrogen levels did not significantly affect number of leaves per plant. Application of 80 kg N ha^{-1} produced significantly higher LAI (20.20) as compared to 40 kg N ha^{-1} (16.78) and control (7.93).

4.3. Crop Growth Rate (*CGR*)

The growth rate of the plant can be used as an appropriate criterion for estimating the potential of the plant community and indicates the slope of dry matter accumulation in the plant. Fig. 5 shows the trends of crop growth rate based on days after planting due to nitrogen uptake to maturity. According to Fig. 5, the crop growth rate was slow at the beginning of growth, but then started to increase and reached its peak about 70 days after planting. The highest CGR was obtained at 90 kg N ha at amount 27.35 gr. $m^{-2}.day^{-1}$. After CGR reached its maximum at all four levels of nitrogen treatment, it decreased to zero within 85 days after planting and then negative. Observing such a trend in the plant, due to the gradual and increasing solar radiation absorption, as the leaf area index increases, the dry matter accumulation rate in the plant increases. Over time, the rate of dry matter accumulation after it reached to final level, with leaf aging and net photosynthesis decrease and led to reduce crop growth rate.

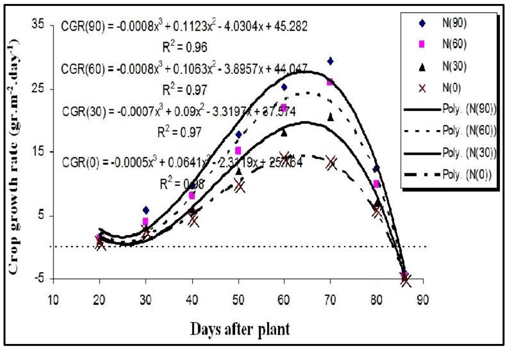

Fig. 5. Trend of regression variation of crop growth rate affected different level of nitrogen.

Decreasing crop growth rate to zero can be attributed to a decrease in net photosynthesis and negative trend of it related to reduce of dry matter at the last stages of plant growth due to leaf fall and negative net photosynthesis. In 90 kg.ha^{-1} nitrogen treatment, due to higher nitrogen content, leaf area increase and canopy spreading in the plant, lower leaf fall at late stages of growth, had lowest decreasing trend. The pattern of changes in crop growth rate influenced by use zinc sulfate and control treatments is shown in Fig. 6. The best-fitting equations showed that the CGR reaction to different levels of nitrogen followed quadratic linear functions.

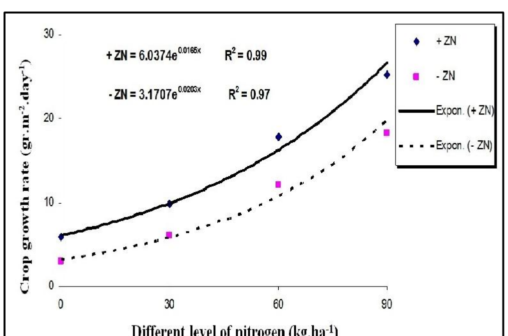

Fig. 6. Trend of regression variation of crop growth rate affected different level of zinc sulfate.

According to the regression equations between these functions, the highest rate of crop growth rate was obtained in zinc sulfate treatment and in high nitrogen treatments of both treatments. It seems that under these conditions, the mentioned treatment with more access to food has been able to provide adequate cover in its canopy and produce more CGR. Since leaves are the major contributor to photosynthesis and dry matter increment per unit area, it can be expected that treatments that produce more leaf area, produce more LAI and have a higher crop growth rate. Because leaves are a major factor to photosynthesis and increase in dry matter per unit area, it can be expected that treatments produce more leaf area, produce more LAI and have a higher crop growth rate. Valadabadi and Farahani (2012) reported that application of nitrogen fertilizer significantly affected the total dry weight (TDW), leaf area index (LAI), relative growth rate (RGR) and crop growth rate (CGR) of maize crop. The highest total dry weight (TDW) (1910 gr.m^{-2}), LAI (4.2), RGR (0.08 gr.gr^{-1}.day^{-1}) and CGR (31.2 gr.m^{-2}.day^{-1}) were obtained with application of 520 Kg urea ha^{-1}, respectively.

4.4. Relative Growth Rate (RGR)

The relative growth rate indicates the amount of dry matter accumulated per unit of primary dry weight of the crop. The highest RGR was obtained at all four levels of nitrogen at the beginning of the growing season (Fig. 7). The higher relative growth rate in the 90 kg.ha^{-1} nitrogen treatment at the beginning of the period was probably due to the higher photosynthetic rate resulting from this treatment and higher efficiency in dry matter production at this time. Relative growth rate due to change in photosynthesis and respiration crop situation.

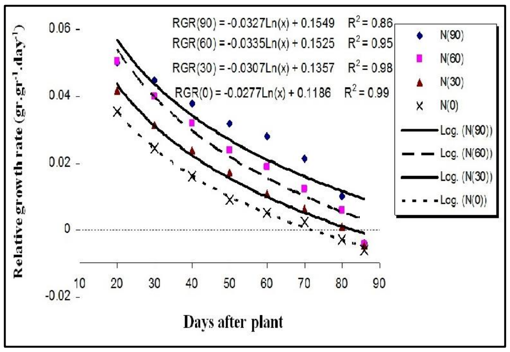

Fig. 7. Trend of regression variation of relative growth rate affected different level of nitrogen.

As a result, by increase age of lower, stay leaves in shade and fall, dry matter accumulation, increase in respiration and reduce CGR led to become negative RGR at the end of the growing season (Tadayon and Emam, 2007). Fig. 8 shows the trends of variation of relative growth rate from the beginning of the growth period to maturity under the influence of different levels of nitrogen (0, 30, 60 and 90 kg.ha^{-1} nitrogen) with zinc sulfate and control treatments. The RGR reaction is affected by the different levels of the above treatments per unit time in descending order. The RGR reaction is affected by the different levels of the above treatments per unit time has descending trend. The highest relative growth rate at the beginning of the growth period was achieved at 0.037 gr.gr^{-1}.day^{-1} from zinc sulfate treatment. The decrease of RGR with increasing age of plant was more severe in the early stages of growth and gradually decreased with past time. In general, the slope of relative growth rate curve shows the rate of dry matter accumulation in the plant.

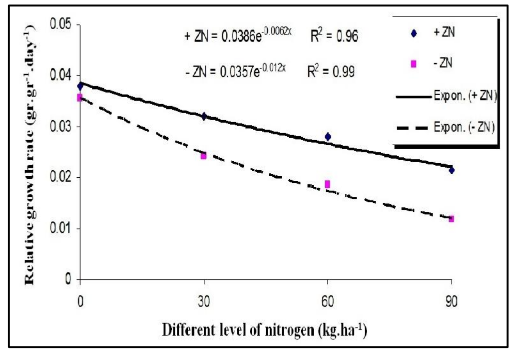

Fig. 8. Trend of regression variation of relative growth rate affected different level of zinc sulfate.

The relative growth rate of zinc sulfate treatment was slower than the control treatment and therefore the dry matter accumulation rate was faster (Fig. 8).

4.5. Net Assimilation Rate (*NAR*)

The NAR represents the rate of carbon fixation and, in other words, is the dry matter production per unit area of leaf per unit time. NAR is also a criterion for estimating the actual photosynthetic potential of a leaf in a plant community. As can be seen in Fig. 9, at all nitrogen levels, the rate of net uptake at the beginning of the growth period was highest. In that time most leaves are exposed to direct sunlight. The advantage of this stage is because of the low LAI at this time and it is not important in terms of dry matter production. NAR is a suitable criterion for expression of plant growth characteristics.

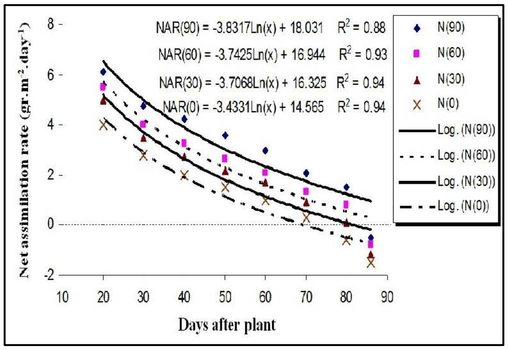

Fig. 9. Trend of regression variation of net assimilation rate affected different level of nitrogen.

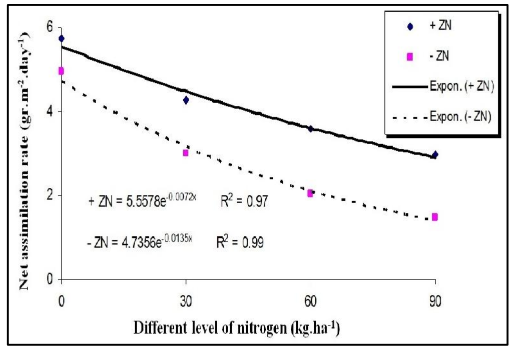

Fig. 10. Trend of regression variation of net assimilation rate affected different level of zinc sulfate.

Since leaves are the major factor in plant photosynthesis, growth expression based on leaf area seems more favorable. The NAR variations at the different levels were initially the same, but then the slope of the curve related to nonuse of nitrogen treatment declined further, which could be due to yellowing and earlier leaf fall in this treatment (Fig. 9). Although amount of NAR levels were different in use and non-use of zinc sulfate at different levels of nitrogen was different, but the rate of NAR reduction at the end of growth period was slower in zinc sulfate treatment (Fig. 10). It seems this treatment can finished the photosynthesis, growth and development process completely and used light more efficiently. Increase in net assimilation rate (NAR) is attributed to increased photosynthetic capacity of the leaves with improved nutrition of the plants (Ahmad *et al.*, 1990). The NAR and relative growth rate (RGR) improve with the increasing levels of N (Warraich *et al.*, 2002). Ayub *et al.* (1995) reported an increase by 20.3% in protein content of wheat grains with higher levels of nitrogen application.

Lopes *et al.*, (2011b) reported with five cultivars of the genus Cynodon, recorded RGR values of 0.084 $gr.gr^{-1}.day^{-1}$ (21 to 28 growth days) and 0.026 $gr.gr^{-1}.day^{-1}$ (28 to 35 growth days). The pattern of response (reduction) in the RGR at more advanced ages (end of the cycle) can be ascribed to the progressive increase in plant weight, since the RGR= (1/W).(dW/dt), as well as to the decrease in the values of NAR and LAR, since the RGR derives from the product of these two growth indices; the first, a physiological component, and the second, a morphological component (Lopes *et al.*, 2011c). Watson *et al.* (1966) reported NAR reduction is mainly due to the drop in the photosynthetic rate that occurs with increased respiratory losses of the plant. Importantly, NAR is not only determined by the photosynthetic rate, but also by the size of leaf area, in addition to the duration of vegetative period, architecture of upper part, translocation, and assimilate partitioning. This increase in NAR in response to increasing nitrogen fertilizer levels is due to the increase in the number of cells, leading to a higher development of leaves with higher photosynthetic potential. The greater availability of nitrogen affects the photosynthesis because it is a component of chlorophyll molecule and part of the molecular structures of the entire protein synthesis apparatus involved in the photosynthetic process. In fact, there are reports of increased photosynthetic rate and the relative chlorophyll index in response to the levels of nitrogen fertilizer (Lopes *et al*., 2011a). Rahman *et al*. (2000) who reported that nitrogen application created a significant impact on leaf photosynthesis, leaf area index, crop growth rate and biomass production of wheat.

5. CONCLUSION

Nutrient deficiencies can be corrected by simply applying appropriate fertilizers (nitrogen in this case), but it is neither practicable nor economical to attempt to eliminate the deficiencies to maximize crop production by massive application of fertilizers. Rather the fertilizers should be applied sparingly to each crop, with the allowance for all practical and economical factors that are involved as well as the actual deficiency levels in the soils. Final result of current study revealed use of 90 $kg.ha^{-1}$ nitrogen with consume zinc sulfate treatment led to achieve maximum level of growth indices in compare to another treatments and can advise to farmers in studied region.

ACKNOWLEDGMENT

The authors thank all colleagues and other participants, who took part in the study.

FOOTNOTES

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

FUNDING/SUPPORT: This study was done by scientific support of Department of Agronomy, Islamic Azad University, Khuzestan Science and Research Branch.

REFRENCES

Adeniji, A. A. and S. Ehiermere. 2003. Effects of replacing maize with sorghum offal in the diets of weaner rabbits. J. Agri. Res. Develop. 2: 1-6.

Ahmad, N., R. Ahmad. S. Bokhari. and A. Ghani. 1990. Physiological determinants of growth and yield in wheat as affected by different levels of nitrogen and phosphorous. Pak. J. Agri. Sci. 27: 390-404.

Ahmed, A., M. A. Randhawa. and M. W. Sajid. 2014. Bioavailability of calcium, iron, and zinc in whole wheat flour. In: Wheat and rice in disease prevention and health benefits, risks and mechanisms of whole grains in health promotion. *In*: Watson, R. R., V. Preedy. and S. Zibadi. (Eds). 1st Ed. Acad. Press. USA. pp. 67-80.

Albayrak, S., C. S. Sevimay. and O. Tongel. 2006. Effect of inoculation with *Rhizobium* on seed yield and yield components of common vetch (*Vicia sativa* L.). Turkish J. Agri. Forestry. 30: 31-37.

Alam, M. Z. and S. A. Haider. 2006. Growth attributes of barley (*Hordeum Vulgare* L.) cultivars in relation to different doses of nitrogen fertilizer. J. Life and Earth Sci. 1(2): 77-82.

Ali, H., M. A. Khan. and Sh. A. Randhawa. 2004. Interactive effect of seed inoculation and phosphorus application on growth and yield of chick pea (*Cicer arietinum* L.). Intl. J. Agri. Biol. 6(1): 110-112.

Ayub, M., S. Guertin. and D. L. Smith. 1995. Nitrogen fertilizer rate and timing effect on bread wheat protein in Eastern. Can. J. Agron. Crop Sci. 174: 337-339.

Begum, A., A. Ahad. and M. O. Kaisar. 2003. Effect of sowing dates and fertilizer treatments on the reproductive variability of French bean (*Phaseolus vulgaris*). Pak. J. Biol. Sci. 6(22): 1897-1901.

Caliskan, S., I. Ozkaya, M. E. Caliskan. and M. Arslan. 2008. The effect of nitrogen and iron fertilization on growth, yield and fertilizer use efficiency of soybean in Mediterranean type soil. Field Crops Res. 108: 126-132.

Cástor Omar Ponce, G., P. J. M. Soto, E. Sánchez, E. Muñoz-Márquez, F. J. Piña-Ramírez, M. A. Flores-Córdova, R. Pérez-Leal. and R. M. Yáñez Muñoz. 2019. Efficiency of nanoparticle, sulfate, and zinc-chelate use on biomass, yield, and nitrogen assimilation in green beans. Agronomy. 9(128): 1-11.

Dauda, S. N., E. B. Amans, H. Mani. and R. A. Yahaya. 2015. Yield and yield components of green bean (*Phaseolus vulgaris* L.) varieties response to nitrogen and phosphorus rate. Gashua Journal of Irrigation and Desertification Studies. 1(1-2): 57-68. *In*: Adelson, P. A., Mercelo, G .T .J. and Dejaio, L. A. 2000. Growth and yield of common bean varieties at two soil phosphorus level, under biological nitrogen fixation. Pesquisa Agropecuaria Brasileira. 35(4): 809-817.

El-Awadi, M. E., A. M. El-Bassiony, Z. F. Fawzy. and M. A. El-Nemr. 2011. Response of Snap Bean (*Phaseolus vulgaris* L) plants to nitrogen fertilizer and foliar application with methionine and tryptophan. J. Nature and Sci. 9(5): 87-94.

Erman, M., S. Demir, E. Ocak, S. Tufenkci, F. Oguz. and A. Akkopru. 2011. Effects of *Rhizobium*, arbuscular mycorrhiza and whey applications on some properties in chickpea (*Cicer arietinum* L.) under irrigated and rainfed conditions 1-Yield, yield components, nodulation and AMF colonization. Field Crops Res. 122(1): 14-24.

FAOSTAT. 2017. Green Bean World Statistics. Major food and agricultural commodities producers-Countries by commodity. Available online: www.faostat.fao.org (accessed on 23 October 2017).

Ghasempour, R. and M. Ashori. 2014. Impact of various planting spaces and different levels of nitrogen fertilizer on yield and yield components of green beans (cultivated) under the weather of Guilan (Province). Indian J. Fundamental and Appl. Life Sci. 4(4): 2950-2956.

Grzebisz, W., M. Wronska, J. B. Diatta. and P. Dullin. 1999. Effect of zinc foliar application at an early stage of maize growth on patterns of nutrients and dry matter accumulation by the canopy. I: Zinc uptake patterns and its redistribution among maize organs. J. Elementology. 13: 17-28.

Gupta, U. C. 1989. Effect of zinc fertilization on plant zinc concentration of forages and cereals. Can. J. Soil Sci. 69: 473-479.

Gupta, N. K. and S. Gupta. 2005. Plant Physiology. Oxford and IBH Publ. pp. 580.

Guu, J. W., T. C. Yang. and T. Y. Fong. 1995. Effects of organic manure on the growth and yield of common bean at fall season bulletin of Taichung. District Agricultural Improvement Station. 49: 41-48 (Cited from Horticultural Abstracts, CBA.1997. 67: 4).

Hani, A. E., A. Muna. and A. E. E. Hamad. 2006. The effect of nitrogen and phosphorus fertilization on growth, yield and quality of fodder maize (*Zea mays* L.). J. Agronomy. 5(3): 515-518.

Heinemann, A. B., L. F. Stone, D. D. Agostinho, M. G. Trindade, B. B. Soares, J. A. A. Moreira. and A. D. Canovas. 2006. Solar radiation use efficiency on the wheat grain yield as a function of nitrogen fertilizer. Rev. Bras. Eng. Agric. Ambient. 10: 352-356.

Hokmalipour, S. and M. Hamele Darbandi. 2011. Physiological Growth Indices in Corn (*Zea mays* L.) Cultivars as Affected by Nitrogen Fertilizer Levels. World Applied Sciences Journal. 15(12): 1800-1805. *In*: Tesar, M. B. 1984. Physiological basis of crop growth and development. Am. Soc. Agronomy. Madison. Wisconsin. USA. pp: 291-321.

Khavarinejad, R., F. Najafi. and R. Firozeh. 2011. Effects of zinc sulfate on some physiological parameters of bean plant. J. Plant Sci. Res. 21(6): 1-14. (Abstract in English)

Kibe, A. M., S. Singh. and N. Karla. 2006. Water nitrogen relationship for wheat growth and productivity in late sown conditions. Agri. Water Management. 8(4): 221-228.

Lincoln, T. and Z. Edvardo. 2006. Assimilation of mineral nutrition. In: Plant Physiology (4th Edition), Sinaur Associates. Inc. Pub. Sunderland. 705 pp.

Lopes, M. N., R. C. Fernandes Franco Pompeu, M. J. Duarte Cândido, C. F. de Lacerda, R. G. da Silva. and F. R. Belem Fernandes. 2011a. Growth index in massai grass under different levels of nitrogen fertilization. Revista Brasileira de Zootecnia. 40(12): 2666-2672.

Lopes, M. N., R. C. Fernandes Franco Pompeu, M. J. Duarte Cândido, C. F. de Lacerda, R. G. da Silva. and F. R. Belem Fernandes. 2011b. Growth index in massai grass under different levels of nitrogen fertilization. Revista Brasileira de Zootecnia. 40(12): 2666-2672. *In*: Gomide, C. C. C. 1966. Algumas características morfológicas e químicas de cinco cultivares de *Cynodon*. 100f. Dissertação- Universidade Estadual São Paulo, Jaboticabal.

Lopes, M. N., R. C. Fernandes Franco Pompeu, M. J. Duarte Cândido, C. F. de Lacerda, R. G. da Silva. and F. R. Belem Fernandes. 2011c. Growth index in massai grass under different levels of nitrogen fertilization. Revista Brasileira de Zootecnia. 40(12): 2666-2672. *In*: Alexandrino, E., J. A. Gomide. and C. A. M. Gomide. 2005. Crescimento e desenvolvimento do dossel de *Panicum maximum* cv. Mombaça. Revista Brasileira Zootecnia. 34(6): 2164-2173.

Mahady, A. E. M. 1990. Effect of phosphorus fertilizer, some micronutrients and plant density on growth and yield of broad beans. Ph.D. Thesis. Faculty of Agriculture. Moshtohor. Zagazig University. Egypt.

Mbeke, A. M., S. C. Kirui, N. C. Kibet, A. M. Welinga, S. K. Musyoki. and C. M. Nguta. 2014. Effects of nitrogen application on snap beans production in Koibatek district Kenya. Intl. J. Develop. Sust. 3(5): 1013-1025.

McKenzie, B. A. and G. D. Hill. 1995. Growth and yield of two chickpea (*Cicer arietinum* L.) varieties in Canterbury, New Zealand. New Zealand J. Crop and Horti. Sci. 23: 467-474.

Mohan, S., M. Singh. and R. Kumar. 2015. Effect of nitrogen, phosphorus and zinc fertilization on yield and quality of kharif fodder: A review. Agri. Rev. 36(3): 218-226.

Mohammadian, M. 2002. Final report of research project: Evaluation of nitrogen application in different N-supplying capacity soils on rice yield. Rice Res. Institute of Iran. 47 pp.

Namvar, A., R. Seyed Sharifi, M. Sedghi, R. Asghari Zakaria, T. Khandan. and B. Eskandarpour. 2011a. Study on the effects of organic and inorganic nitrogen fertilizer on yield, yield components and nodulation state of chickpea (*Cicer arietinum* L.). Communications in Soil Sci. Plant Analysis. 42(9): 1097-1109.

Namvar, A., R. S. Sharifi. and T. Khandan. 2011b. Growth analysis and yield of chickpea (*Cicer arietinum* L.) in relation to organic and inorganic nitrogen fertilization. Ekologija. 57(3): 97-108.

Negash, A., S. Tulu. and E. Getachew. 2018. Yield and yield components of Snap Bean (*Phaseolus vulgaris* L.) as affected by N and P fertilizer rates at Jimma, southwestern Ethiopia. Adv. Crop Sci. Tech. 6(3): 1-5.

Nicolas, S. R., A. E. E. Jose, T. R. G. Maria. and S. M. Eliseo. 2011. Yield and nutritional quality of snab bean in terms of bio-fertilization. Tropical and Subtropical Agro Eco-system 13: 347-355.

Pandey, N., G. C. Pathak. and C. P. Sharma. 2006. Zinc is critically required for pollen function and fertilization in lentil. J. Trace Element and Medical Biol. 20(2): 80-96.

Poblaciones, M. J. and Z. Rengel. 2016. Soil and foliar zinc biofortification in field pea (*Pisum sativum* L.): Grain accumulation and bioavailability in raw and cooked grains. Food Chem. 212: 427-433.

Prasad, T. N. V. K. V., P. Sudhakar, Y. Sreenivasulu, P. Latha, V. Munaswamy, K. R. Reddy. and T. Pradeep. 2012. Effect of Nano scale zinc oxide particles on the germination, growth and yield of peanut. J. Plant Nutrition. 35: 905-927.

Pedersen, P. E. 1966. Zinc, an overlooked nutrient. Agricultural Chemistry. January 1966. pp: 26-27.

Rahman, M. A., A. J. M. S. Karim, M. M. Hoque. and K. Egashira. 2000. Effects of irrigation and nitrogen fertilization on photosynthesis, leaf area index and dry matter production of wheat on a clay terrace soil of Bangladesh. J. Fac. Agric. Kyushu Univ. 45: 289-300.

Ranjbar, G. A. and M. A. Bahmaniar. 2007. Effects of soil and foliar application of Zn fertilizer on yield and growth characteristics of Bread Wheat (*Triticum aestivum* L.) cultivars. Asian J. Plant Sci. 6: 1000-1005.

Redford, P. J. 1967. Growth analysis formulae their use and abuse. Crop Sci. 7: 171.

Sajedi, N. A., M. R. Ardakani, A. Naderi, H. Madani. and M. M. A. Boojar. 2009. Response of maize to nutrients foliar application under water deficit stress conditions. **Salvagiotti, F., K. G. Cassman, J. E. Specht, D. T. Walters, A. Weiss. and A. Dobermann. 2008.** Nitrogen uptake, fixation and response to N in soybeans: A review. Field Crops Res. 108: 1-13. American Journal of Agricultural and Biological Sciences. 4: 242-248.

Sena, R., M. A. Rahmanb, A. K. M. S. Hoquea, S. Zamanb. and S. Noora. 2010. Response of Different Levels of Nitrogen and Phosphorus on the Growth and Yield of French Bean. Bangladesh J. Sci. Ind. Res. 45(2): 169-172.

Sharma, R., R. Choudhary. and B. Jat Lal. 2017. Effect of nitrogen and zinc fertilization on growth and productivity of maize. Intl. J. Agric. Sci. 13(2): 161-176.

Shahzad, Z., H. Rouached. and A. Rakha. 2014. Combating mineral malnutrition through iron and zinc biofortification of cereals. Comprehensive Reviews in Food Science and Food Safety. 13(3): 329-346.

Sommer, A. L. and C. B. Lipman. 1996. Evidence on the indispensable nature of zinc and boron for higher green plant. Plant Physiol. 1: 231-249.

Sida-Arreola, J. P., E. Sánchez, P. Preciado-Rangel. and C. Márquez-Quiroz. 2017. Does zinc biofortification affects the antioxidant activity in common bean?. Cogent Food and Agriculture. 3: 1-7.

Srinivas, K. and L. B. Naik. 1988. Response of vegetable French bean (*Phaseolus vulgaris*) to nitrogen and phosphorus fertilization. Indian J. Agri. Sci. 58(9):707-708.

Tadayon, M. R. and Y. Emam. 2007. Physiological and morphological responses of two barley cultivars to salinity stress in relation to grain yield. J. Water. Soil. Sci. 11(1): 253-263. (Abstract in English)

Tahir, M., N. Fiaz, M. A. Nadeem, F. Khalid. and M. Ali. 2009. Effect of different chelated zinc sources on the growth and yield of maize (*Zea mays* L.). Soil and Environ. 28(2): 179-183.

Thalooth, A. T., N. M. Badr. and M. H. Mohamed. 2005. Effect of foliar spraying with Zn and different levels of Phosphatic fertilizer on growth and yield of sunflower plants grown under saline condition. Egyptian J. Agronomy. 27: 11-22.

Ullah, G., E. A. Khan, I. U. Awan, M. A. Khan, A. A. Khakwani, M. S. Baloch, Q. Ullah Khan, M. S. Jilani, K. Wasim, S.Javeria. and Gh. Jilani. 2013. Wheat response to application methods and levels of nitrogen fertilizer: I. phenology, growth indices and protein content. Pak. J. Nutrition. 12(4): 365-370.

Umer, S., S. K. Bansal, P. Imas. and H. Magen. 1999. Effect of foliar fertilization of potassium on yield, quality and nutrient uptake of groundnut. J. Plant Nutrition. 22: 1785-1795.

Valdabadi, S. A. and H. A. Farahani. 2012. Effects of planting density and pattern on physiological growth indices in maize (*Zea mays* L.) under nitrogenous fertilizer application. J. Agri. Extension and Rural Development. 2(3): 40-47.

Walley, F. L., S. K. Boahen, G. Hnatowich. and C. Stevenson. 2005. Nitrogen and phosphorus fertility management for desi and kabuli chickpea. Canadian Journal of Plant Sci. 85: 73-79.

Warraich, E. A., N. Ahmed, S. M. A. Basra. and I. Afzal. 2002. Effect of nitrogen on source-sink relationship in wheat. Intl. J. Agri. Biol. 4: 300-302.

Watson, D. J., J. H Wilson. and M. A. Ford. 1966. Changes with age in the photosynthetic and respiratory components of the net assimilation rates of sugar beet and wheat. New Phytologist. 65(4): 500-508.

Wilson, J. W. 1981. Analysis of growth, photosynthesis and light interception for single plants and stands. Annals of Botany. 48(3): 507-512.

World Health Organization (WHO). 2002. World health report. Reducing risks, promoting healthy life, Geneva. Switzerland.

Yasari, E. and A. M. Patwardhan. 2006. Physiological analysis of the growth and development of canola (*Brassica napus* L.) under different chemical fertilizer application. Asian J. Plant Sci. 5(5): 745-752.

Zajac, T., S. Grzesiak, B. Kulig. and M. Polacek. 2005. The estimation of productivity and yield of linseed (*Linum usitatissimum* L.) using the growth analysis. Acta Physiologiae Plantarum. 27(4): 549-558.