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# Effect of Combined Zinc and Nitrogen on Yield, Chemical Constituents and Nitrogen Use Efficiency of Some Chickpea Cultivars under Sandy Soil Conditions

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**Abstract:** Two field experiments were carried out at the Agricultural Production and Research Station, National Research Centre, Nubaria Province, Behaira Governorate, Egypt, during the two successive winter seasons 2010/2011and 2011/2012 to study the effect of foliar applied Zn at different growth stages (flowering and seed filling stages) combined with N levels (30 or 60 kg N/faddan, one faddan= 0.42ha) on yield, chemical constituents and nitrogen use efficiency of two chickpea cultivars (Giza-2 and Giza-88). The results show that chickpea cultivars significantly differed in plant height, weight of pods/ plant, seed and straw yields/faddan, nitrogen and protein contents in the seeds. Giza-88 cultivar significantly surpassed Giza-2 cultivar in plant height, number of pods/plant, weight of pods/plant, seed yield/plant, seed and straw yields/faddan. The combination of Zn foliar application at different growth stages and nitrogen fertilizer treatments resulted significant effects on plant height, number and weight of pod/plant, seed yield/plant and seed, straw and biological yields/faddan. Increasing N levels from 30 to 60 kg N /faddan without Zn application increased significantly yield and its components i.e. plant height, number and weight of pods /plant, seed yield /plant, N and protein contents in the seed. Application of nitrogen levels in combination with Zn as foliar application either at flowering or seed filling stages exhibited significant increases in most of the studied characters compared to without Zn application. The highest values of the most studied characters were recorded by treatment 60 kg N /faddan+ Zn foliar application at seed filling stage followed by the treatment of 60 kg N /faddan + Zn foliar application at flowering stage. It seems that Giza 88 was more responsive to the greater N dose and Zn ( 60kg N /faddan + Zn foliar spraying applied at the seed filling stage) than Giza -2 under the same conditions of this study. It could be concluded that chickpea plants favor the lower rates of applied N than the higher rates when grown under the newly reclaimed sandy soils and the cultivars were differed in their ability to utilize N efficiently. Also, late application of Zn especially at the seed filling period increased the ability of chickpea plants to use N effectively.

**Key words:** Chickpea · Nitrogen fertilizer · Zinc application · Yield

## INTRODUCTION

Chickpea is one of the most important legume crops in Egypt as it offers human nutrition with vegetable protein. Chickpea is a good source of protein, carbohydrate, minerals (phosphorus, calcium, magnesium, iron and zinc) and β-carotene moreover its protein quality is better than most other legumes [1]. It can be a very useful legume crop for incorporation into short-term rotation and for fixation of nitrogen in soil and its fertility [2]. Crop production can be improved through improving the metabolic activity and nutritional status of crop plants. In this respect, Zinc (Zn) has an important metabolically role in plants growth and development and is therefore called an essential trace element or a micronutrient. Zinc is uptake and transfers the form of $Zn^{2+}$ in plants and is an essential nutrient that has particular physiological functions in all living systems, such as the maintenance of structural and functional integrity of biological membranes and facilitation of protein synthesis and gene expression, enzymes structure, energy production and Krebs cycle; also has a

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positive impact on crops yield; therefore crops quantitative and qualitative yield is strongly dependent on zinc (Zn) in the soil [3, 4, 5]. Micronutrient availability for the plant depends, among other factors, texture, organic matter and mainly soil pH. The sandy soil texture is characterize very low organic matter, low water holding capacity and high nutrient losses by leaching these tend to deficiency of macro and micro-nutrient in semiarid regions. It was recently documented that Zn foliar application is a simple way for making quick correction of plant nutritional status, as reported for green gram [6] and chickpea [4]. Zinc foliar application had positive effects on plant height and seed yield [7]. The yield potential of chickpea could be regulated through alternation of genetically makeup. Increasing chickpea yield per unit area can be achieved by breeding high yielding varieties. Significant differences in chickpea varieties have been shown by Bakhsh *et al.* [8], Ahmed *et al.* [9], Akay [10], El-Habbasha *et al.* [11] and Rabieyan and Fakharian [12].

Therefore, this study aimed to investigate the effect of foliar applications of Zn at different growth stages and N fertilizer levels on yield, chemical constituents and nitrogen use efficiency of some chickpea cultivars grown under newly reclaimed sandy soils.

## MATERIALS AND METHODS

Two field experiments were carried out at the Agricultural Production and Research Station, National Research Centre, Nubaria Province, Behaira Governorate, Egypt during the two successive winter seasons 2010/2011and 2011/2012 to study the effect of nitrogen fertilizer and foliar zinc application at different growth stages on yield, yield attributes and some chemical traits of chickpea cultivars. Physical and chemical properties of soil (0-30 depth) in the experimental site were determined according to the method described by Chapman and Pratt [13] as follows: sand 91.2%, silt 3.7%, clay 5.1%, pH 7.3, organic matter 0.3 %, $CaCO_3$, 1.4%, EC 0.3 dS/m, soluble N 8.1 ppm, available P 3.2 ppm and available K 0.3 ppm. The treatments were arranged in split plot design with three replications where the chickpea cultivars (Giza-2 and Giza-88) occupied the main plots, while sub-plots were devoted to N fertilization levels 30 and 60 kg N/faddan (one faddan=0.42ha) and Zn foliar application treatments (0.2 % $ZnSO_4$ $7H_2O$) at different growth stages (without Zn, flowering and seed filling stages), the treatments were arranged randomly in the subplots. Seeds of chickpea were planted on November 16$^{th}$ and 20$^{th}$ in the first and second seasons, respectively, 10 cm between hills at a seeding rate of 60 kg/faddan. Phosphorus fertilizer as calcium superphosphate, 15.5 % $P_2O_5$ at 30 kg $P_2O_5$/faddan and potassium fertilizer as potassium sulfate, 48 % $K_2O$ were added during the seedbed preparation, while nitrogen fertilizer was added as ammonium sulfate, 20.6 % in three equal doses at 15, 30 and 45 days after sowing (DAS). Organic fertilizer was added before preparing the soil at a rate of 20 $m^3$/faddan. Sprinkler irrigation was applied as plants needed. Normal cultural practices were followed. At maturity, a sample of ten random guarded plants from the middle rows of each plot were taken to determine plant height (cm), number of pods per plant, weight of pods and seeds per plant(g), as well as harvest index. Seed, straw and biological yields (ton/faddan) were determined from the whole plot. Nitrogen use efficiency (NUE) is defined as seed yield produced per unit of total N supply as reported by Sowers *et al.* [14]. NPK content in seed and straw were determined according to the method described by A.O.A.C. [15] and the seed protein content was calculated by multiplying total nitrogen concentration by 6.25.

**Statistical Analysis:** The data obtained was statistically analysis according to Snedecor and Cochran [16] and the combined analysis was made for the two growing seasons according to Steel and Torrie [17]. The treatment means were compared by using L.S.D test at 5% level of probability.

## RESULTS AND DISCUSSION

**Effect of Cultivars Differences on Yield and Yield Attributes of Chickpea:** Data presented in Table 1 indicated that chickpea cultivars significantly differed in plant height, weight of pods /plant, seed yield/plant, straw yield/faddan, nitrogen and protein contents in the seed. Giza-88 cultivar significantly surpassed Giza-2 cultivar in plant height, number of pods/plant, weight of pods/plant, seed yield/plant, seed and straw yields/faddan. On the other hand, the differences between Giza-88 and Giza-2 cultivars in number of pods/plant, number of seeds/plant, seed and biological yields/faddan did not reach the level of significance. It could be mentioned that the results of the varietal differences in yield and yield components herein, are in full agreement with those obtained by Bakhsh *et al.* [8], Ahmed *et al.* [9], Akay [10], El-Habbasha *et al.* [11], Rabieyan and Fakharian [12]and Shaban *et al.* [18].

Table 1: Effect of cultivars differences on yield and yield attributes of chickpea (combined data of 2010/2011 and 2011/2012 seasons)

| Cultivars | Plant height (cm) | No of pods/plant | Weight of pods/plant (g) | No of seeds/plant | Seed yield/plant (g) | Seed yield (ton/faddan) | Straw yield (ton /faddan) | Biological yield (ton /faddan) |
|---|---|---|---|---|---|---|---|---|
| Giza-2 | 73.40 | 44.85 | 20.55 | 75.57 | 13.42 | 1.31 | 2.21 | 3.51 |
| Giza-88 | 76.52 | 44.92 | 22.15 | 77.70 | 15.22 | 1.38 | 2.28 | 3.66 |
| LSD 0.05 | 2.75 | NS | 1.10 | NS | 0.13 | NS | 0.03 | NS |

Table 1: Continue

| | Seed content (%) | | | Straw content (%) | | | |
|---|---|---|---|---|---|---|---|
| Cultivars | N | P | K | N | P | K | Seed protein content (%) |
| Giza-2 | 3.24 | 0.88 | 0.77 | 1.992 | 0.257 | 1.16 | 20.27 |
| Giza-88 | 3.43 | 0.87 | 0.76 | 1.950 | 0.250 | 1.14 | 21.41 |
| LSD 0.05 | 0.09 | NS | NS | NS | NS | NS | 0.21 |

Table 2: Effect of nitrogen fertilizer and zinc foliar application at different growth stages on yield and yield attributes of chickpea (combined data of 2010/2011 and 2011/2012 seasons)

| Treatments | Plant height (cm) | Number of pods/plant | Weight of pods/plant (g) | Number of seeds/plant | Seed yield/plant (g) | Seed yield (ton/faddan) | Straw yield (ton /faddan) | Biological yield (ton /faddan) |
|---|---|---|---|---|---|---|---|---|
| 30 kg N/faddan + without Zn | 70.15 | 39.71 | 16.90 | 70.34 | 12.12 | 1.17 | 1.96 | 3.13 |
| 30 kg /faddan +Zn flowering | 71.99 | 42.62 | 19.69 | 74.52 | 12.72 | 1.22 | 2.10 | 3.32 |
| 30 kg N/faddan +Zn seed filling | 75.18 | 44.39 | 22.03 | 76.21 | 13.92 | 1.29 | 2.19 | 3.49 |
| 60kg N /faddan+ without Zn | 73.17 | 43.90 | 20.54 | 74.87 | 14.22 | 1.41 | 2.29 | 3.70 |
| 60 kg N /faddan +Zn flowering | 77.86 | 47.84 | 23.71 | 79.94 | 16.62 | 1.46 | 2.34 | 3.80 |
| 60 kg N /faddan +Zn seed filling | 81.43 | 50.85 | 25.21 | 83.92 | 16.32 | 1.51 | 2.57 | 4.08 |
| LSD 0.05 | 1.03 | 0.94 | 0.86 | 6.11 | 0.43 | 0.09 | 0.02 | 0.41 |

Table 2: Continue

| | Seed content (%) | | | Straw content (%) | | | |
|---|---|---|---|---|---|---|---|
| Treatments | N | P | K | N | P | K | Seed protein content % |
| 30 kg N/faddan + without Zn | 3.16 | 0.87 | 0.73 | 1.931 | 0.250 | 1.13 | 19.72 |
| 30 kg /faddan + Zn flowering | 3.19 | 0.90 | 0.78 | 2.101 | 0.260 | 1.17 | 19.92 |
| 30 kg N/faddan + Zn seed filling | 3.32 | 0.86 | 0.75 | 1.852 | 0.241 | 1.13 | 20.73 |
| 60kg N /faddan + without Zn | 3.26 | 0.89 | 0.78 | 1.920 | 0.251 | 1.15 | 20.39 |
| 60 kg N /faddan + Zn flowering | 3.33 | 0.88 | 0.84 | 2.110 | 0.271 | 1.21 | 20.78 |
| 60 kg N /faddan +Zn seed filling | 3.37 | 0.84 | 0.73 | 1.911 | 0.251 | 1.13 | 21.05 |
| LSD 0.05 | 0.05 | NS | NS | NS | NS | NS | 0.78 |

**Effect of Nitrogen Fertilizer and Zinc Foliar Application at Different Growth Stages on Yield and Yield Attributes of Chickpea:** Data in Table 2 illustrated that the combination of foliar applied Zn at different growth stages (flowering and seed filling stages) and nitrogen fertilizer treatments (30 and 60 kg N/faddan) had a significant effect on plant height, number and weight of pods/plant, seed yield/plant and seed, straw and biological yields/faddan. The physiological role of Zn in nitrogen management was most manifested throughout its greater recovery from nitrogen fertilizer applied at the rate 60 kg N/faddan. Similar results were reported by Salehin and Rahman [19]. Data presented in Table 2 indicated that increasing N levels from 30 to 60 kg N /faddan without Zn application increased significantly yield and its components i.e. plant height, number and weight of pods /plant, seed yield /plant, concentrations of N and protein contents, but did not significantly influence number of seeds/plant. The results are in conformity with Dalvand and Mehranzadeh [20], who reported that nitrogen fertilizer improves the conditions and enhances soil enzyme activity and provides nitrogen in the soil, which reflect in increasing yield and its components and protein content.

Application of nitrogen fertilizer at the rate of 30 and/or 60 kg N /faddan in combination of foliar application with Zn either at flowering or seed filling stages significantly increased most of the studied characters compared to the treatments without Zn application. The highest values of the most studied characters was recorded by the treatment 60 kg N/ faddan+ Zn foliar application at seed filling stage, the increment reached to 7, 12 and 10% over the treatment

Table 3: Effect of interaction between varietal differences, nitrogen fertilizer and zinc foliar application at different growth stages on yield and yield attributes of chickpea (combined data of 2010/2011 and 2011/2012 seasons)

| Treatments | | Plant height (cm) | No of pods/plant | Weight of pods/ plant (g) | No of Seeds/plant | Seed yield/ plant (g) | Seed yield ton/ faddan | Straw yield ton/faddan | Biological yield ton/faddan | Seed protein content % |
|---|---|---|---|---|---|---|---|---|---|---|
| Giza-2 | 30 kg N/faddan + without Zn | 68.93 | 40.65 | 15.83 | 71.78 | 11.12 | 1.12 | 2.01 | 3.13 | 19.69 |
| | 30 kg /faddan + Zn flowering | 70.05 | 42.62 | 18.88 | 71.88 | 12.42 | 1.16 | 2.01 | 3.18 | 19.53 |
| | 30 kg N/faddan + Zn seed filling | 72.32 | 43.90 | 20.73 | 74.17 | 12.82 | 1.25 | 2.18 | 3.43 | 20.91 |
| | 60kg N /faddan + without Zn | 73.00 | 44.59 | 19.75 | 74.87 | 13.02 | 1.38 | 2.19 | 3.56 | 20.03 |
| | 60 kg N /faddan + Zn flowering | 76.50 | 46.86 | 23.23 | 77.95 | 15.42 | 1.43 | 2.26 | 3.68 | 20.53 |
| | 60 kg N /faddan + Zn seed filling | 79.64 | 50.50 | 24.89 | 82.73 | 15.72 | 1.50 | 2.59 | 4.09 | 20.91 |
| Giza-88 | 30 kg N/faddan + without Zn | 71.38 | 38.78 | 17.98 | 68.90 | 13.12 | 1.22 | 1.91 | 3.13 | 19.75 |
| | 30 kg /faddan + Zn flowering | 73.93 | 42.62 | 20.50 | 77.16 | 13.02 | 1.27 | 2.18 | 3.45 | 20.31 |
| | 30 kg N/faddan + Zn seed filling | 78.04 | 44.89 | 23.34 | 78.25 | 15.02 | 1.34 | 2.20 | 3.54 | 20.56 |
| | 60kg N /faddan + without Zn | 73.35 | 43.21 | 21.34 | 74.87 | 15.42 | 1.45 | 2.39 | 3.84 | 20.75 |
| | 60 kg N /faddan + Zn flowering | 79.23 | 48.83 | 24.20 | 81.93 | 17.82 | 1.50 | 2.42 | 3.92 | 21.03 |
| | 60 kg N /faddan + Zn seed filling | 83.23 | 51.19 | 25.53 | 85.12 | 16.92 | 1.52 | 2.54 | 4.06 | 21.19 |
| LSD 0.05 | | 1.46 | 1.32 | 1.22 | 8.64 | 0.15 | 0.13 | 0.03 | 0.58 | 0.50 |

60 kg N/ faddan + without Zn foliar application followed by treatment 60 kg N /faddan+ Zn foliar application at flowering stage. The increase in yield and its components by foliar fertilizer with Zinc may be due to the easily absorbed forms of nutrients by leaves. Zinc is required for chlorophyll production, pollen function, fertilization and germination [21, 22, 23]. Chickpea is a highly responsive crop to micronutrient fertilizer in general, Zn in particular and his deficiency may be one of the important reasons of poor yield [4]. Several studies pointed out to the positive response of yield to Zn foliar application [6] in green gram and [19] in faba bean. In this respect, Shaban *et al.* [18] showed that application of Zn fertilizer had better effect on grain yield and yield components compared to the control. Recently, Dalvand and Mehranzadeh [20] indicated that Zn fertilizer had a positive effect on the seed yield and biomass yield of chickpea. In chickpea, the final seed yield is dependent upon the number of pods per plant, number of seeds per pod and the extent to which seeds are filled. Hadi *et al.* [7] reported that Zinc foliar application had positive effects on plant height and seed yield. Foliar application of Zn led to an increase in concentrations of N, P and K in both seed and straw and protein content which was mainly due to the vital physiological role of Zn in plant cell.

**Effect of Interaction Between Chickpea Cultivars, Nitrogen Fertilizer and Zinc Application on Yield and Yield Attributes of Chickpea:** Application of 60 kg N /faddan+ Zn foliar application applied at the seed filling stage recorded the highest values of all characteristics for both cultivars Giza 88 and Giza-2 without significance differences between them in number of pods/plant and weight of pods/plant. However, application of 30 kg N /faddan + without Zn recorded the lowest values of these characters in Giza-2 (Table 3). Such differential behaviour of various cultivars to Zn foliar application may be attributed to their variable genetic make up and physiological mechanism of plants carried out in the presence of Zn as foliar application. Data shown in Fig. 1, 2 and 3 illustrated that N, P and K content in both seed and straw affected by the interaction between chickpea cultivars x Zn foliar application at flowering and seed filling stages and nitrogen fertilizer. Data also clearly indicated that Giza-88 fertilized with 60 kg N/faddan + Zn foliar application at the seed filling stage gave the highest value of N in seed, meanwhile, Giza-2 fertilized with 60kg N /faddan+ Zn foliar application at flowering stage produced highest significant N, P and K in straw.

**Effect of Zn Foliar Application at Different Growth Stages on Nitrogen Use Efficiency (Nue) of Chickpea Cultivars:** Data presented in Fig. 4 and 5 show the effect of Zn application on chickpea ability in greater NUE expressed as kg seeds/kg N applied. Generally, the data show that foliar applied Zn increased NUE by chickpea plants by 8 and 9% at flowering and seed filling stages, respectively compared to the untreated plants and regardless nitrogen applied level. Data also indicated that Giza-88 possessed a slight greater ability in using nitrogen and the chickpea plants responded positively to the lower nitrogen level than the higher level. Nitrogen use efficiency expressed as kg seeds/kg N applied under 30 kg N level reached 39.2 and 42.24 kg seeds for Giza-2 and Giza-88, respectively, while the corresponding values when the plants fertilized with 60 kg N/faddan were 23.94 and 24.83 kg seeds/kg N applied, respectively. Application of Zn led to greater NUE when it was applied at grain filling stage than flowering stage and ranged between 3 and 12 % when the plants were fertilized with 30 kg N/faddan, while it was 3 and 8% with 60 kg N/faddan at grain filling and flowering stages, respectively. These results clearly indicated that the synergistic effect of Zn application to chickpea plants fertilized with nitrogen especially at the lower level which reflected as greater yield units per nitrogen utilized unit.

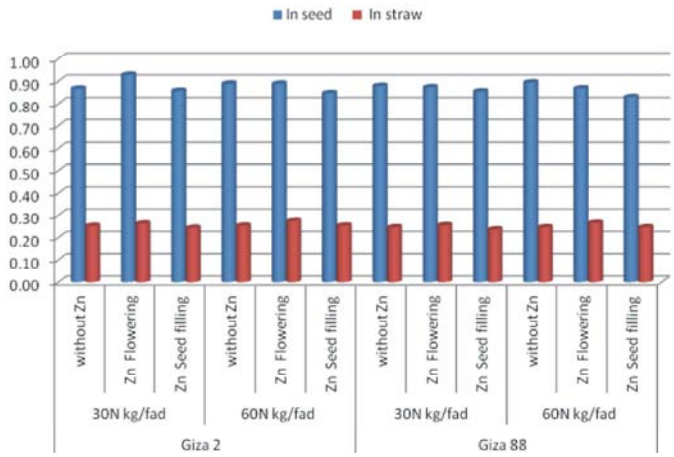


Fig. 1: Effect of interaction between chickpea cultivars, nitrogen fertilizer and zinc foliar application at different growth stages on nitrogen percentage

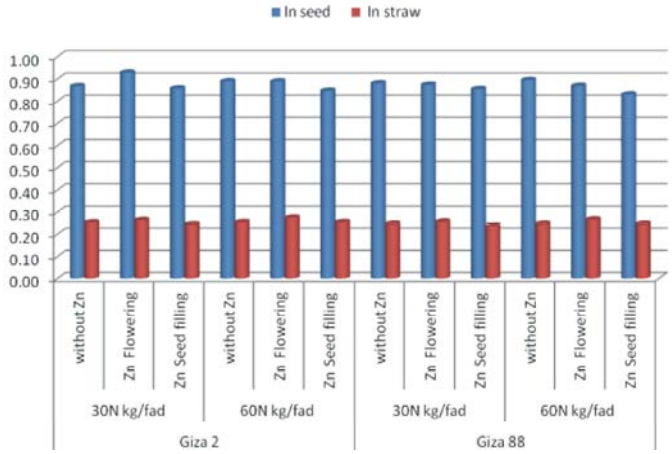


Fig. 2: Effect of interaction between chickpea cultivars, nitrogen fertilizer and zinc foliar application at different growth stages on phosphorus percentage

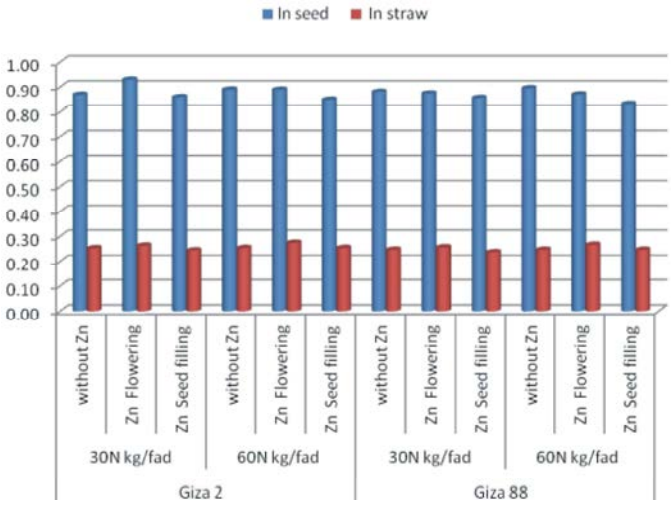


Fig. 3: Effect of interaction between chickpea cultivars, nitrogen fertilizer and zinc foliar application at different growth stages on potassium percentage

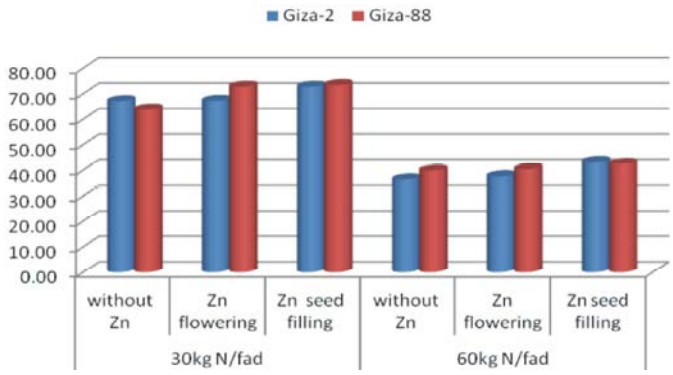


Fig. 4: Effect of nitrogen fertilizer and zinc foliar application at different growth stages on nitrogen use efficiency of Giza 2 and Giza 88 straw

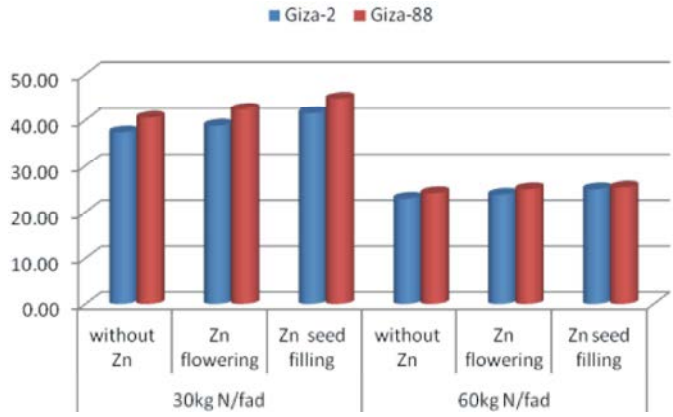


Fig. 5: Effect of nitrogen fertilizer and zinc foliar application at different growth stages on nitrogen use efficiency of Giza 2 and Giza 88 seeds

These results are in harmony with those obtained by Gan *et al.* [24], who reported that increasing N fertilizer rates decreased NUE, with the rate of decrease being greater for noninoculated chickpea compared with inoculated chickpea.

## CONCLUSION

It could be concluded that chickpea plants favour the lower rates of applied nitrogen than the higher rates under the newly reclaimed sandy soils and differ in their ability to utilize nitrogen efficiently according to the cultivar. Also, late application of Zn especially at the seed filling period increased the ability of chickpea plants to use nitrogen effectively.

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