



ISSN NO. 2320-5407

Journal homepage: <http://www.journalijar.com>

INTERNATIONAL JOURNAL  
OF ADVANCED RESEARCH

## RESEARCH ARTICLE

**Effect of foliar application of proline and zinc on Growth, Yield and Some Metabolic Activities of  
*Chenopodium quinoa* Plants**

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**Manuscript Info****Manuscript History:**

Received: 14 November 2015  
Final Accepted: 15 December 2015  
Published Online: January 2016

**Key words:**

quinoa, foliar treatment,  
proline, zinc

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**Abstract**

This research examines the actual growth, yield and certain metabolic activities of quinoa plants in response to foliar treatments with Proline 25 ppm and Zn 50 ppm. Plants were grown in natural clay loamy soil conditions and treated with every of the aforementioned treatments. The treated plants showed significant responses in most of the growth and yield characteristics (lengths of shoots and roots, number of branches/plant, number of leaves/plant, plant biomass and weight of 1000-seed). Also, these treatments caused significant increases in the contents of photosynthetic pigments, soluble carbohydrates, soluble proteins, total phenols, endogenous phytohormone and mineral elements. This was the case during the entire duration of time period of the experiment

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**Introduction**

Increasing yield for an ever growing world population has currently become a topic of great concern with regard to food security. Especially in Africa, agricultural productivity has not been able to cope with population growth, leading to increased annual imports and food insecurity Mugo *et al.* (2005).

Quinoa (*Chenopodium quinoa*) is one of the most important economic crops belongs to the family chenopodiaceae. It is able to grow under conditions normally inhospitable to other cereals. These conditions include low rainfall, high altitude, sub-freezing or high temperatures Ahamed *et al.* (1998). In comparison to other cereal, it has a higher protein content, better amino acid composition, minerals, and vitamin values and also has a high oil content meet or exceed the requirements of human De Bruin (1964). It is considered to be the most yield-limiting micronutrient in crop production in various parts of the world (Fageria and Baligar, 2005 and Duffy, 2007).

Quinoa has enormous potential in the food industry being gluten-free and highly nutritious Doweidar and Kamel (2011). This is of great importance for the nutritional value of pseudo cereals, because a high content of dietary fibre has positive effects on the reduction of the cancer risk. In general, quinoa contained higher total mineral contents than the other cereals such as rye and wheat (FAO, 2011).

In fact Improvement of crops in both quantity and quality is among the goals of the modern applied science and technology. In this regard, the effects of spray of amino acid as proline. Proline is a multifunctional amino acid that besides acting as an excellent osmolyte is also known for stabilizing sub-cellular structures such as proteins and cell membranes, scavenging free radicals, balancing cellular homeostasis and signaling events and buffering redox potential under stress conditions (Szabados and Savoure, 2009).

Plant nutrition one of the most important factors that increase plant production. Zinc (Zn) is an essential nutrient required in some fertilizer programs for crop production. While some soils are capable of supplying adequate amounts for crop production, addition of zinc fertilizers is needed for others Mousavi *et al.* (2012).

The scope of the present analysis would be to discover the potent results of proline, zinc on growth and productivity of quinoa plant.

## Material and Methods

### 1. Methods of planting, treatments and collection of samples

Uniform quinoa seeds were planted in Botanical garden; Botany and Microbiology Dept., Fac. of Sci., Al-Azhar Univ., Nasr City, Cairo, Egypt, Seeds of quinoa were sown in plots (4 m width and 10 m length). The plot contained 12 rows, 70 cm apart and the hills were spaced at 20 cm distance. Lit of seeds were sown in each hill, and the stand was later thinned to two plant per hill. Land preparations, agricultural operations followed the normal practices of crops cultivation in the clay loamy soils, the 12 rows divided into 6 groups representing the following treatments:

1. Tap water (control).
2. Proline (25 ppm).
3. Zinc (50 ppm).

The plants of *Chenopodium quinoa* were treated triple with the above mentioned treatments (as foliage spraying). The first treatment was made when the age of plants was 30 days, while the second treatment was made when the age of plants was 60 days and the third treatment was made when the age of plants was 90 days. The plant samples were collected for analysis when the plants were 40 (Stage I), 70 (Stage II) and 100 (stage III) days old. At the end of the growth season (170 days), analyses of the seeds yielded from the different treatments as well as the control were done.

Table 1. Physical properties of the used soil (as percentage %)

Texture class	Sand	Clay	Silt
Clay loamy	30.70	47.81	22.14

Table 2. Chemical properties of the used soil

TSS ppm	pH	E.C. mmhos/cm	Cations meq/L				Anion meq/L			
			Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>++</sup>	Mg <sup>++</sup>	Cl <sup>-</sup>	SO <sub>4</sub> <sup>--</sup>	HCO <sub>3</sub> <sup>-</sup>	CO <sub>3</sub> <sup>--</sup>
768	7.9	2.65	2.5	0.5	2	1	4	1	1	Zero

### 2. Measurement of growth parameters

Shoot length (cm), root length (cm), number of leaves per / plant, number of branches per / plant, fresh and dry weights of shoots (g/plant), fresh and dry weights of roots (g/plant), weight of 1000-seeds (g) were determined at different growth stages.

### 3. Chemical analysis

Photosynthetic pigments were estimated using the method of Vernon and Selly (1966). Contents of soluble carbohydrates were measured according to the method of Umbriet *et al.* (1969). Contents of soluble proteins were estimated according to the methods of Lowery *et al.* (1951). Phenolic compounds were estimated according to the methods of Daniel and George (1972). Contents of endogenous GA, IAA, JA and ABA were estimated using HPLC according to the method of Knecht and Brunima (1973) and Mineral elements according to the method of Chapman and Pratt (1978).

#### 4. Statistical methods

All statistical calculations were done using computer programs. Microsoft excel version 10 and spss (statistica package for the social science version 20.00) statistical program. at 0.05 level of probability (Snedecor and Cochran, 1989) the One-way ANOVA was presented using, mean  $\pm$  standard error. The discernment, Automatic linear models analysis and conical discriminant functions were estimated to show the relationship of the physiological parameter to each other. (Härdle and Simar, 2007).

### Results and Discussion

#### 1. Growth and Yield Responses

It was revealed from results (figures 1-9) that significant differences were reported for all studied traits of seeds. One of the most of investigated growth qualities percentage were (shoot length (I;16.50% , II ; 13.12%, III 3.67 %) and root length (I;15.12% , II ; 3.36%, III 5.88 %), number of leaves/plant (I;9.50% , II ; 19.05%, III 39.71%), number of branches/plant (III ; 20.21), fresh weight of shoots ( I;59.55% , II ; 95.43%, III 9.35 %), dry weight of shoots ( I;-8.33% , II ; 78.57%, III 22.37 %), fresh weight of roots ( I;0% , II ; 69.57%, III 15.15 %) ,dry weight of root ( I;20% , II ; 128.57%, III 27.15 %) and the weight of 1000-seeds 21.39%) of quinoa plant life have been markedly significant increase when compared with control plant .Responding to the application of Pro. These consequences had been more powerful with the levels I, II and III of development. The stimulative effects of Proline on plant growth were also obtained by many workers Gamal El-Din and Abd El-Wahed (2005) showed that a foliar application of 50 mg·L<sup>-1</sup> ornithine and 100 mg·L<sup>-1</sup> proline increased plant height, number of branches, fresh and dry weights of aerial vegetative parts and flower head of chamomile (*Matricaria chamomilla* L. Rausch). Also El-Sherbeny and Da Silva (2013) indicated that treatment beet root plants with proline at 100 and 200 mg·L<sup>-1</sup> improved plant heights, number of leaves, fresh and dry weight of leaves and roots, root/shoot ratio and root diameter and length. Shahid *et al.* (2014) working on *Pisum sativum* L. plants, reported that significant increase in plant fresh weight, plant dry weight, as well as total chlorophyll contents in response to proline treatment at concentration (60 mM) compared with control plants.

As this has been mentioned in (figures 1-9), Zn had markedly significant increases on all vegetative growth variables percentage of quinoa when compared with control plant. These results are also consistent with Khudsar *et al.* (2004) studied the effect of Zn (50,100,200,300 and 400  $\mu$ g/g soil dry mass) on *Artemisia annua*. They found that, total leaf area, length and dry mass of shoots and roots were increased with the age of plant when being compared with the untreated plants. Zhao *et al.* (2005) found that, the dry weight of shoots and roots in wheat plants were significantly increased due to the treatment with Zn 100  $\mu$ mol/l). Also, Seilsepour (2006) revealed that wheat grain yield, dry matter and 1000 grain weight were increased by use of zinc.

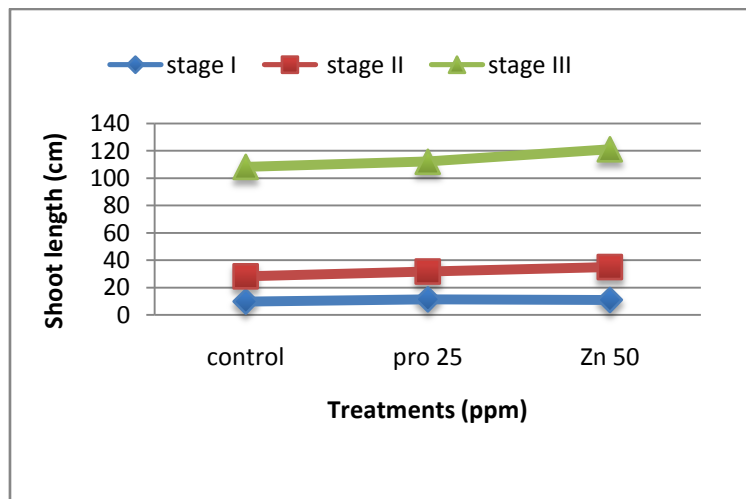


Figure 1. Effect of proline and zinc on shoot length / plant of (*Chenopodium quinoa*) plants

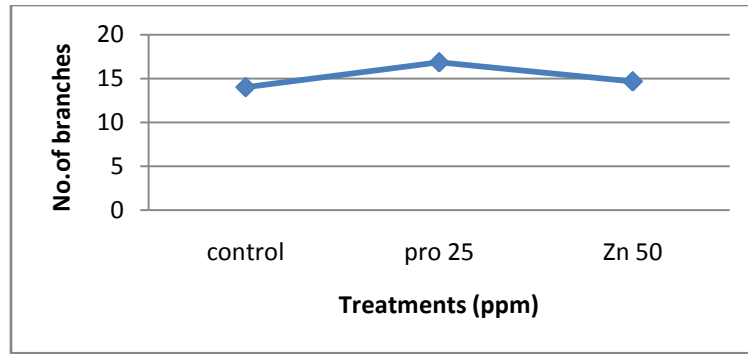


Figure 2. Effect of proline and zinc on No. of branches / plant of (*Chenopodium quinoa*) plants

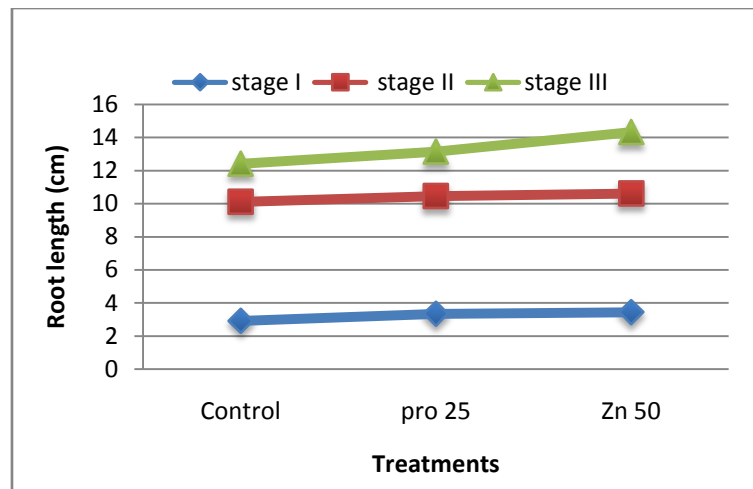


Figure 3. Effect of proline and zinc on root length / plant of (*Chenopodium quinoa*) plants

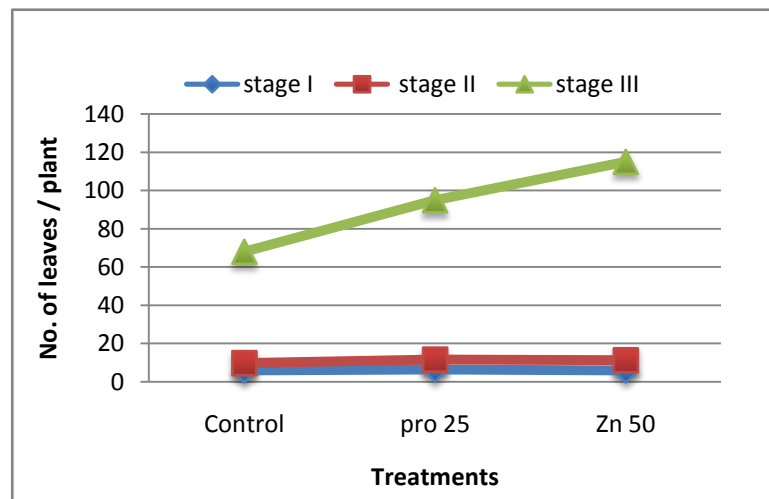


Figure 4. Effect of proline and zinc on no .of leaves / plant of (*Chenopodium quinoa*) plants

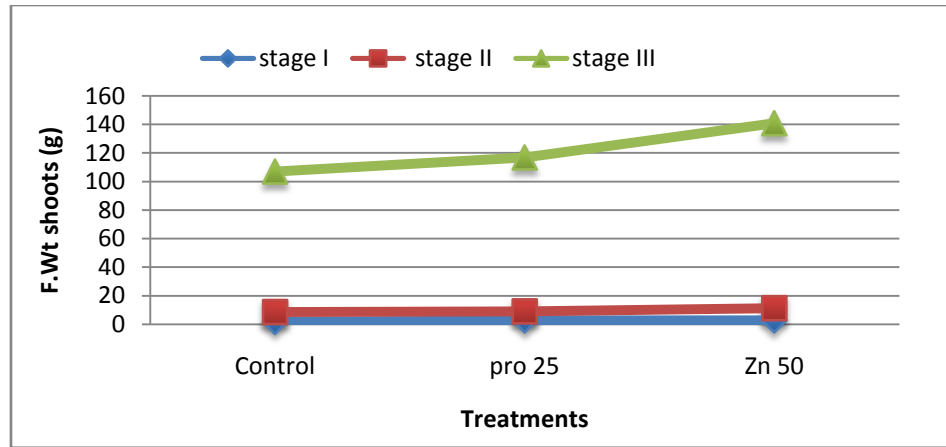


Figure 5. Effect of proline and zinc on fresh weight of shoots / plant of (*Chenopodium quinoa*) plants

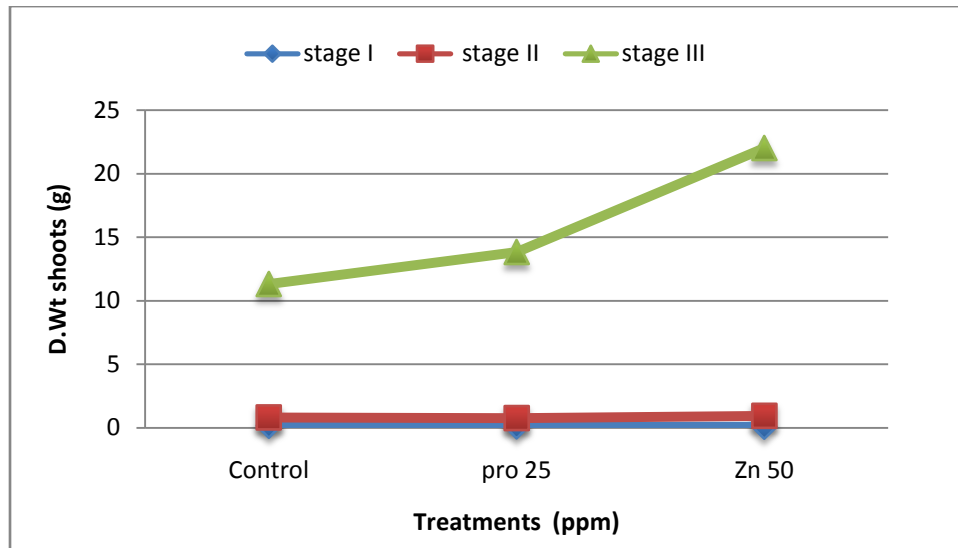


Figure 6. Effect of proline and zinc on dry weight of shoots / plant of (*Chenopodium quinoa*) plants

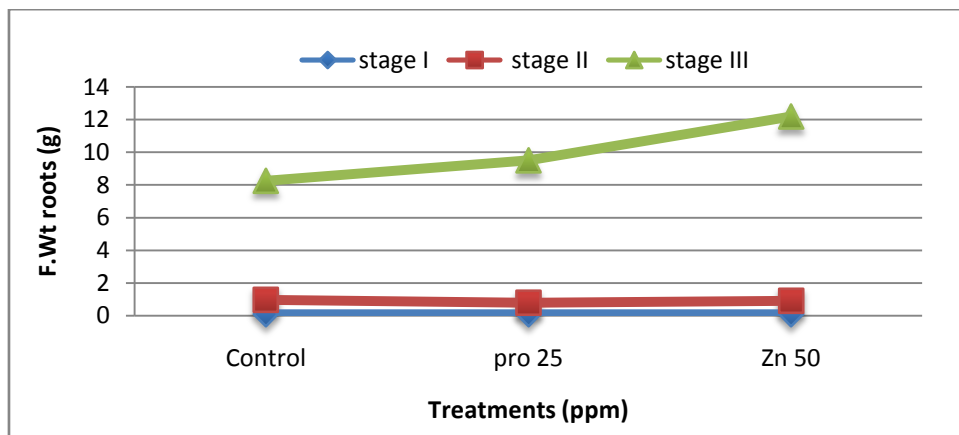


Figure 7. Effect of proline and zinc on fresh weight of roots / plant of (*Chenopodium quinoa*) plants

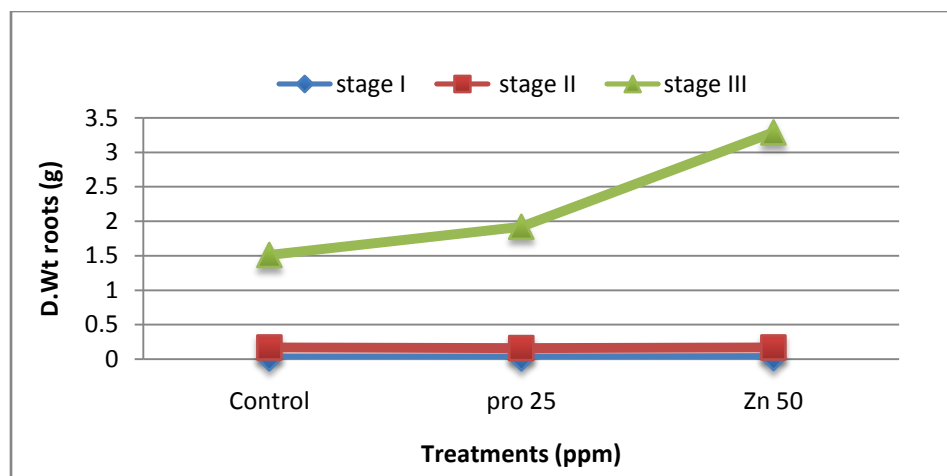


Figure 8. Effect of proline and zinc on dry weight of roots / plant of (*Chenopodium quinoa*) plants

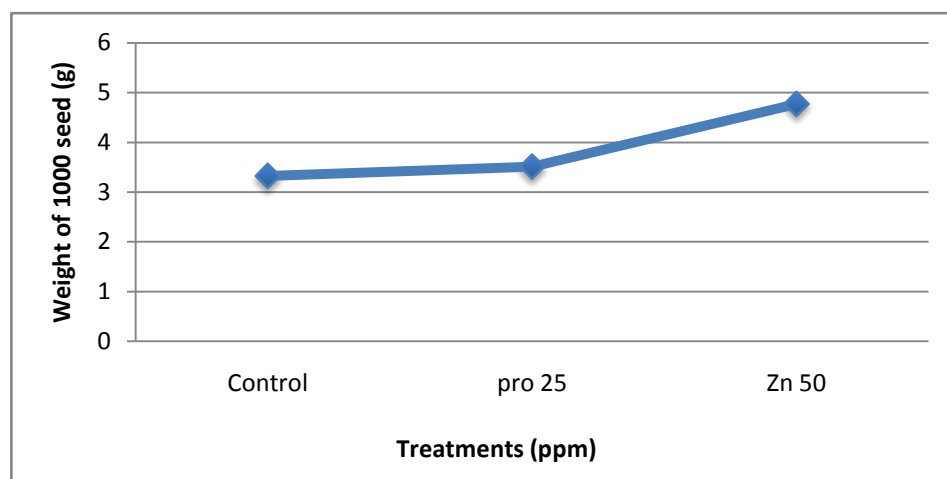


Figure 9. Effect of proline and zinc on weight of seeds / treatment of (*Chenopodium quinoa*) plants

## 2. Photosynthetic Pigments

Outcomes of the present study (figures 10:12) shown that, contents percentage of chlorophyll a (I; 216.29%, II; 272.83%, III; 24.22%), b (I; -32.54%, II; 28.63%, III; 20.21%), and carotenoids (I; 479.31%, II; 612.22%, III; 271.43%), of quinoa plant life were actually dramatically significantly increased in response to the use of Proline.

These results are in agreement with the results obtained by El-Sherbeny and Da Silva (2013) reported that *Beta vulgaris* L. plants treated with proline at concentrations 100, 200 and 400 mg.L<sup>-1</sup> contained more leaf pigments (chl. a and b and carotenoids) and higher carbohydrate content in shoots and roots than the control plants. Khan *et al.* (2014) found that sunflower plants treated with proline at concentrations (30 mmol and 60 mmol) contained more leaf pigments (chl. a and b) when compared to control plant. In this regards, (Fouda, 2013) reported that *Helianthus tuberosus* L plants treated with arginine as amino acid at concentrations 50 and 100 ppm contained more leaf pigments and higher carbohydrates, proteins and phenols contents than that of controls.

With respect to the effect of Zn on chlorophyll content percentage of quinoa plants, the obtained results showed different responses as regards the contents of chlorophylls of the three tested plants. In quinoa plants, application of Zn was found to be, mostly, significant increases percentage as regards the contents of chlorophyll a (I; 121.65%, II; 163.32%, III; 12.60%), b (I; -26.08%, II; .78%, III; 13.54%), and carotenoids (I; 319.54%, II;

473.50%, III; 142.86%). These results are in harmony with those obtained by Akay (2011) found that application of Zn on three types of chickpeas significantly increase leaf chlorophyll concentration. These results are in agreement with the results obtained by Samreen *et al.* (2013) found that application of Zn on mung beans plant (*Vigna radiata*) significantly enhanced chlorophyll and crude protein contents.

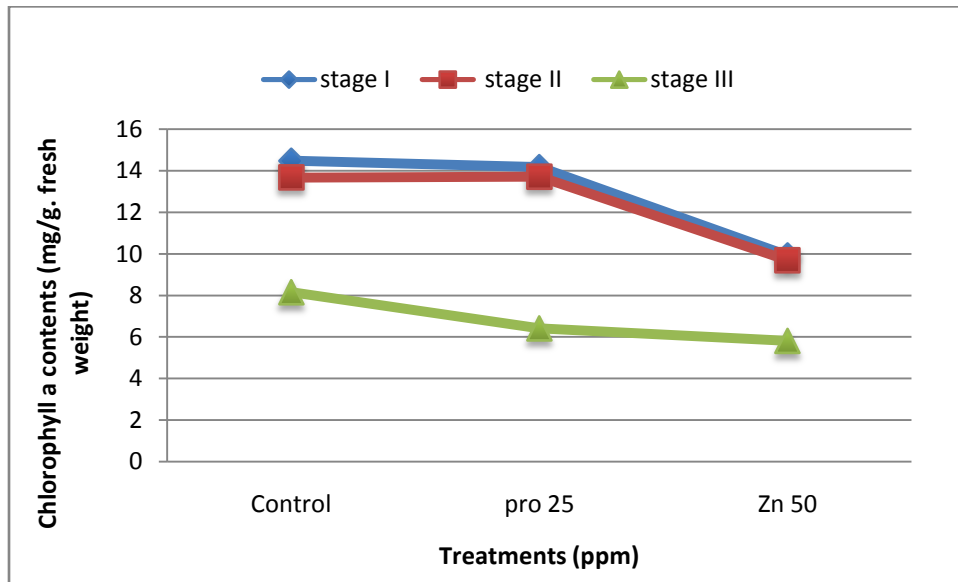


Figure 10. Effect of proline and zinc on chlorophyll (a) contents (mg/g. fresh weight) of (*Chenopodium quinoa*) plants

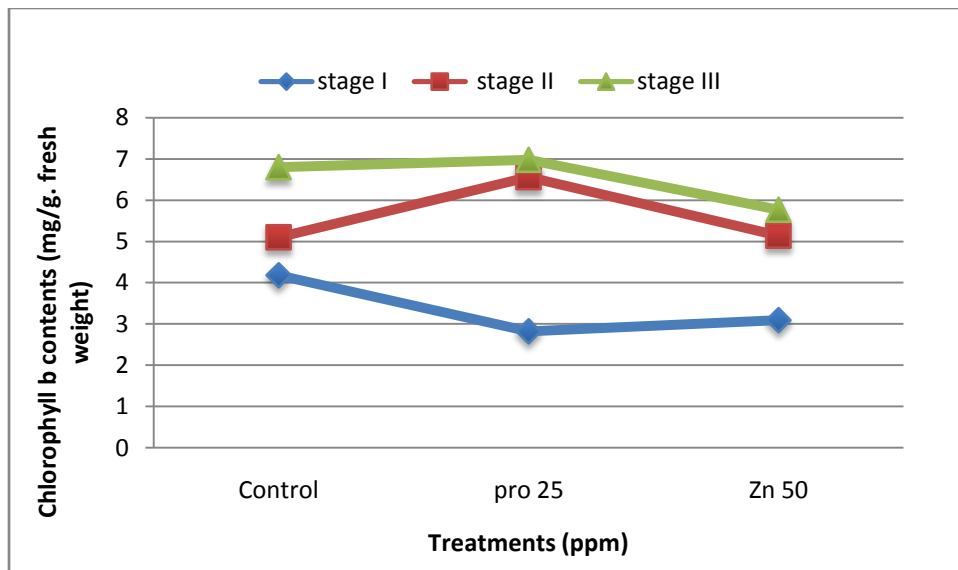


Figure 11. Effect of proline and zinc on chlorophyll (b) contents (mg/g. fresh weight) of (*Chenopodium quinoa*) plants

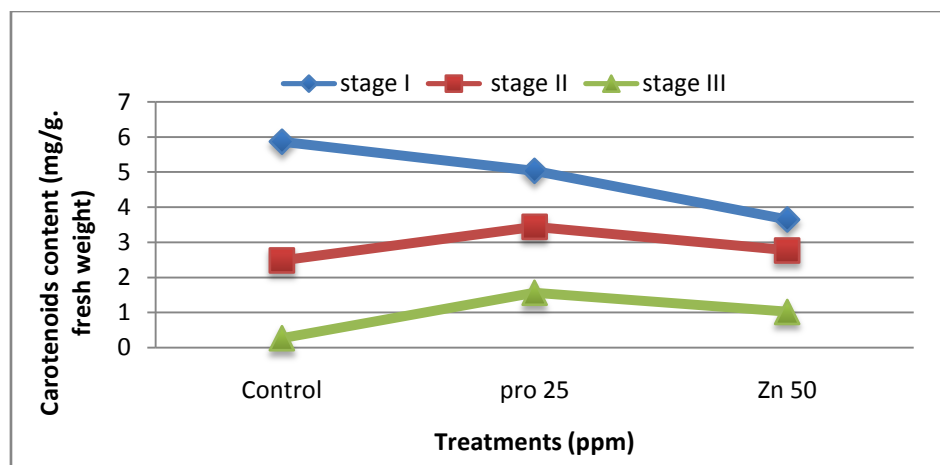


Figure 12. Effect of proline and zinc on carotenoids contents (mg/g. fresh weight) of (*Chenopodium quinoa*) plants.

### 3. Soluble Carbohydrates

Outcomes of the current work (figures 13-14) reported that, contents in total soluble carbohydrates percentage were significantly considerably elevated in shoots (I; 17.84%, II; 24.91%, III; 162.36%) and produced seed products (13.43%) of quinoa plants as a result of the treatment with Proline. It was the situation through the three stages of growth. These effects were more powerful in all stages of growth. The stimulatory results of Pro in regards to contents in total soluble carbohydrates in various plants were recorded by other researchers. El-Sherbeny and Da Silva (2013) reported that *Beta vulgaris* L. plants treated with proline at concentrations 100, 200 and 400 mg.L<sup>-1</sup> contained higher carbohydrate content in shoots and roots than the control plants. Khan *et al.* (2014) indicated that application of proline at concentrations 30 mmol as a foliar spray significantly increased the total sugar of the sunflower plants as compared with control.

In our study, it had been found (figure 13-14) that carbohydrate contents percentage in shoots (I; 23.81%, II; 44.68%, III; 54.72%) as with the produced seed products (37.17%) of quinoa plants were significantly considerably elevated as a result of the remedies with Zn. In accordance with the obtained results, Tobbal (2006) revealed that, contents of total soluble carbohydrates of both *Celosia* and *Zinnia* shoots were significantly increased in response to the treatment with Zn. Also Sofy (2009) reported that application of Zn on broad bean and *Lupinus album* plants significantly increased total soluble carbohydrates in shoots, roots as well as in the yielded seeds.

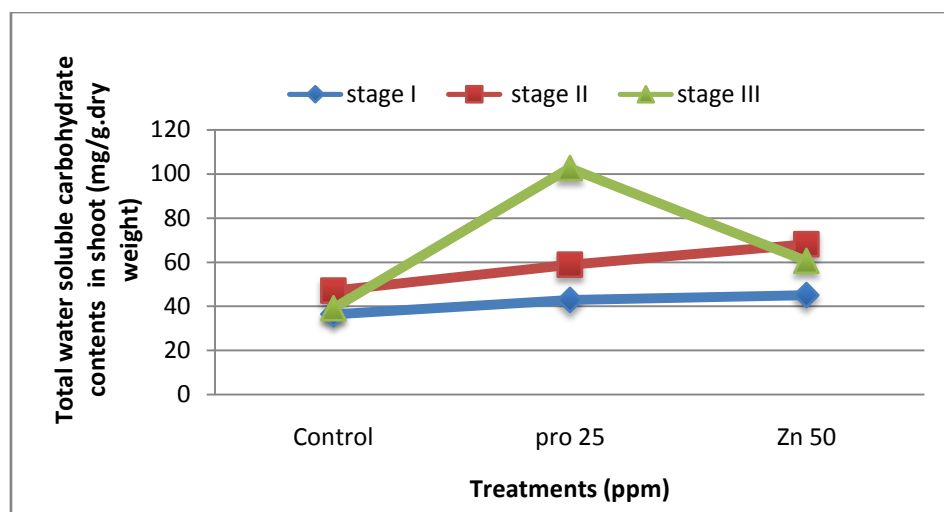


Figure 13. Effect of proline and zinc on total water soluble carbohydrates contents in shoot (mg/g.dry weight) of (*Chenopodium quinoa*) plants

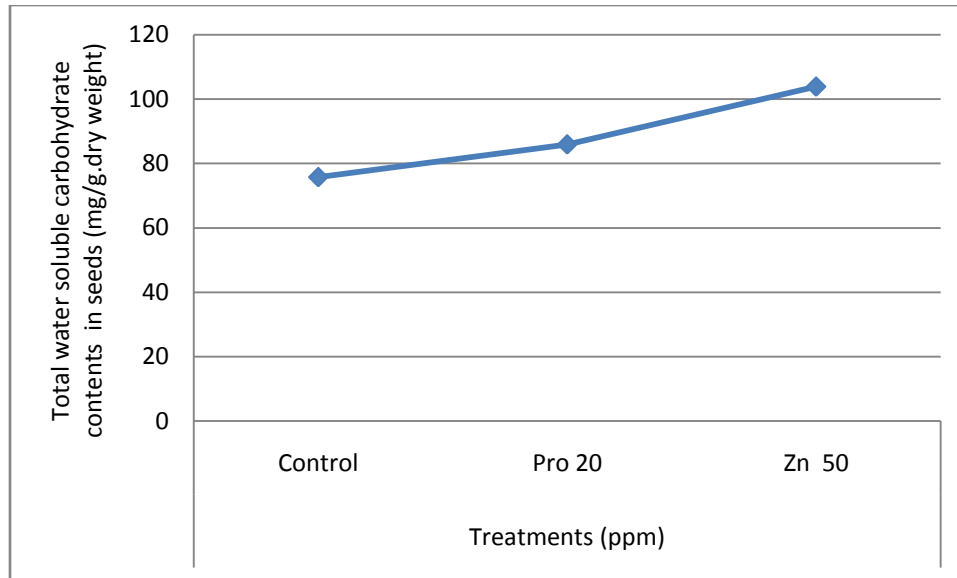


Figure 14. Effect of proline and zinc on total water soluble carbohydrates contents in yield (mg/g.dry weight) of (*Chenopodium quinoa*) plants

#### 4. Soluble Proteins

In our study, it had been found (figures 15 & 16) that protein contents percentage in shoots (I; 11.55%, II; 54.03%, III; 121.67%) as with the produced seed products (36.73%) of quinoa plants were significantly considerably elevated as a result of the remedies with Pro. In compliance using the acquired results, Abd El-Samad *et al.* (2010) noted that the addition of proline at concentration 100 ppm resulted a considerable accumulation in the contents of soluble protein in both shoots and roots of maize and broad bean plants as compared with control ones. . Perveen *et al.* (2013) mentioned that treating two maize (*Zea mays* L.) cultivars with Pro at concentration 30 mM indicated significant increases in proteins comparing with control. Also, Khan *et al.* (2014) indicated that application of proline at concentrations (30 mmol and 60 mmol) as a foliar spray significantly increased the proteins contents in sunflower plants as compared with control.

In our study, it had been found (figures 15 & 16) that protein contents percentage in shoots (I; 27.90%, II; 59.80%, III; 114.47%) as with the produced seed products (41.47%) of quinoa plants were significantly considerably elevated as a result of the remedies with Zn. In compliance using the acquired results. In this regard, Sofy (2009) studied the effect of Zn on broad bean and *lupinus album* plants and found that, the content of soluble protein were increased. Samreen *et al.* (2013) found that application of Zn on mung beans plant (*Vigna radiata*) significantly enhanced crude protein contents. Also, Tajlil *et al.* (2014) investigate the effect of different levels of zinc on biochemical activity of chickpea seeds (*Cicer arietinum*) and found that the effect of zinc on the seed protein levels was significantly increased.

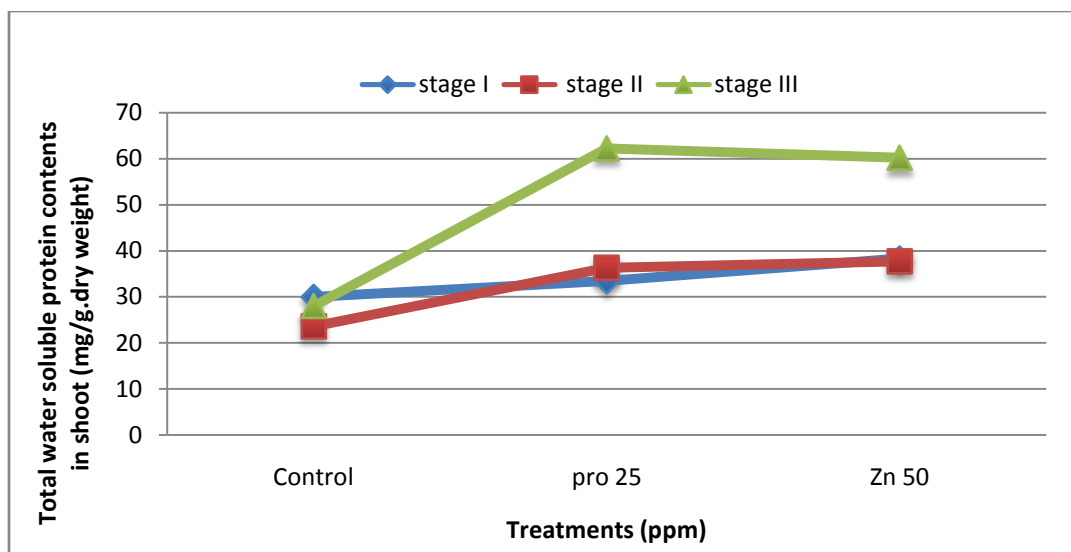


Figure 15. Effect of proline and zinc on total water soluble proteins contents in shoot (mg/g.dry weight) of (*Chenopodium quinoa*) plants

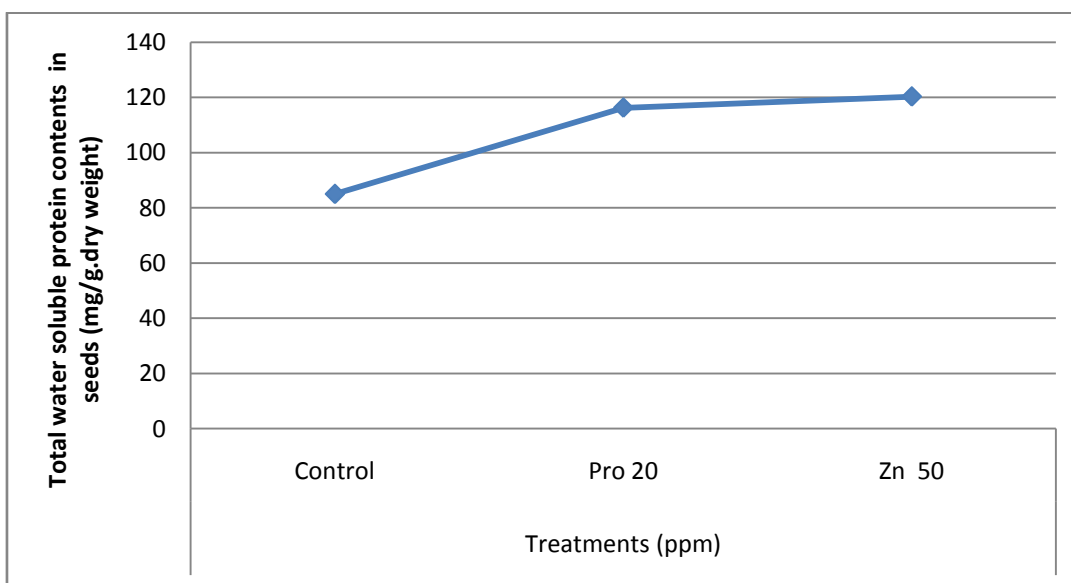


Figure 16. Effect of proline and zinc on total water soluble proteins contents in yield (mg/g.dry weight) of (*Chenopodium quinoa*) plants

## 5. Soluble Phenols

In our study, it had been found (figures 17 & 18) that phenol contents percentage in shoots (I; 37.93%, II; 110%, III; 57.04%) as with the produced seed products (17.33%) of quinoa plants were significantly considerably elevated as a result of the remedies with Proline. In compliance using the acquired results, Perveen *et al.* (2013) mentioned that treating two maize (*Zea mays* L.) cultivars with Proline at concentration 30 mM significantly increased total phenolic compounds comparing with control. Shahid *et al.* (2014) working on *Pisum sativum* L. plants, reported that significant increase in total phenolic contents in response to proline treatment at concentration (60 mM).

In our study, it had been found (figures 17 & 18) that phenol contents percentage in shoots (I; 85.34%, II; 113.33%, III; 95.67%) as with the produced seed products (62.09%) of quinoa plants were significantly considerably elevated as a result of the remedies with Zn. In compliance using the acquired results. In this regard, in the present investigation, it was found total phenols contents in shoots, roots as well as in the yielded seeds of quinoa plants were significantly increased in response to the treatments with Zn. In accordance with the obtained results, Reda *et al.* (2014) reported that treatment faba bean plants with Zn at concentrations 30, 60 mg/l increased total phenolic contents.

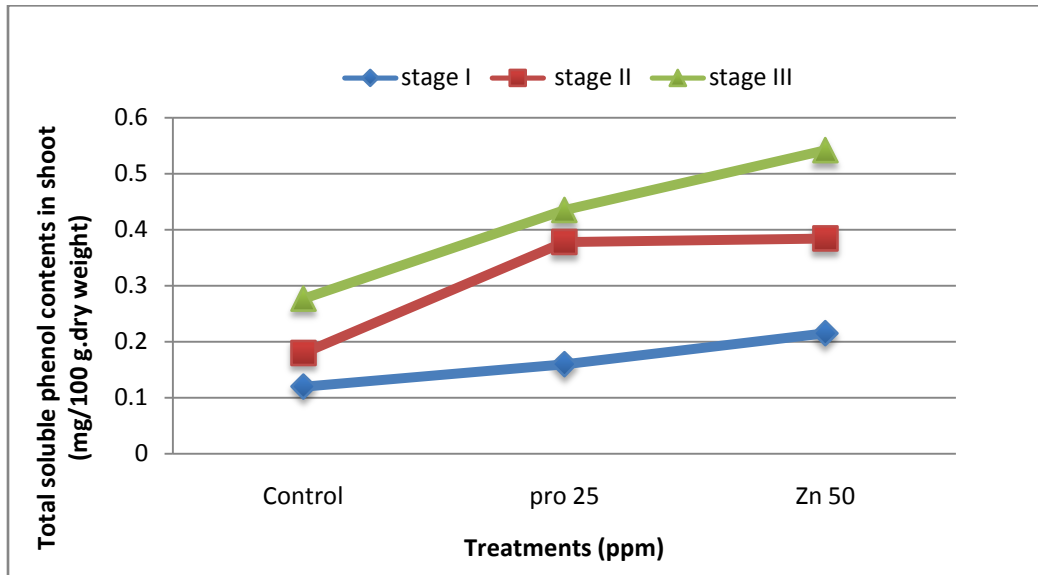


Figure 17. Effect of proline and zinc on total water soluble phenols contents in shoot (mg/100g.dry weight) of (*Chenopodium quinoa*) plants

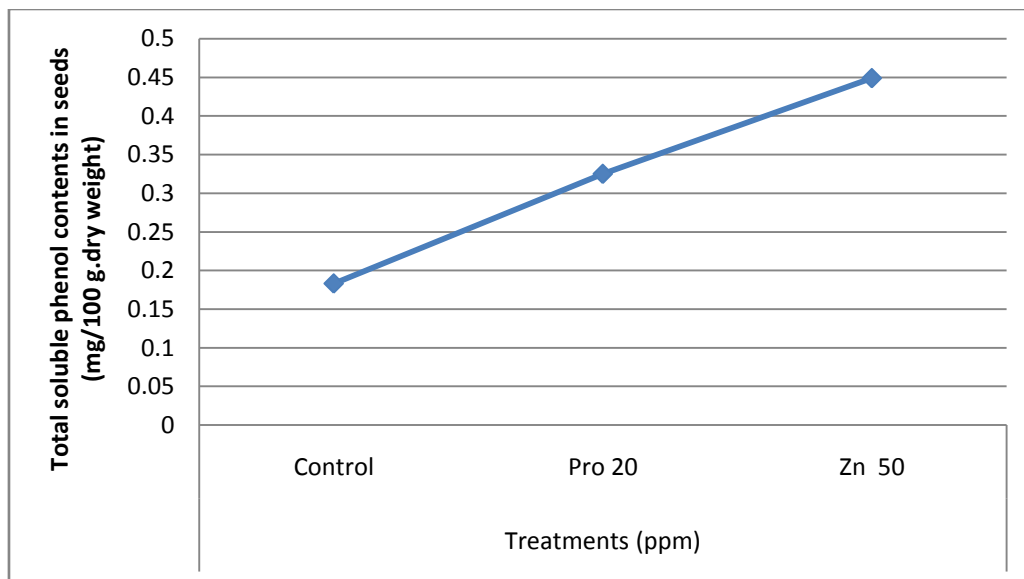


Figure 18. Effect of proline and zinc on total water soluble phenols contents in yield (mg/100g.dry weight) of (*Chenopodium quinoa*) plants

## 6. Endogenous phytohormones

In our study, it had been found (figure 19) reported that, endogenous phytohormones content in shoots ( $GA_3$ ; 14.52%, IAA; -11.22%, CK; 42.22%, ABA-55.56%, JA -14.29%) of quinoa plants were markedly considerably elevated as a result of the remedies with Pro application, treatment with proline resulted in increases in the contents of  $GA_3$  and CK, while contents of IAA, ABA and JA were decreased. Also, Ahmed *et al.* (2014) reported that treating *Ammi visnaga* L plants with amino acid (tyrosine and phenylalanine) resulted in, generally, significant increases in the contents of (IAA,  $GA_3$ , CK) and low level of ABA.

With respect to the treatment with zinc endogenous phytohormones content in shoots ( $GA_3$ ; 50%, IAA; 28.57%, CK; 75.56%, ABA-48.15%, JA -85.71%) of quinoa plants were markedly considerably elevated, increased in activities of  $GA_3$ , IAA and CK. While contents of ABA and JA were decreased. In this regards, Zaky *et al.* (1999) found that, Zn at (10 and 50 ppm) increased the activities of endogenous gibberellins of cowpea plants. Tobbal (2006) reported that Zn treatments greatly increased contents of IAA and  $GA_3$  in both *Celosia* and *Zinnia* plants while contents of ABA were decreased especially at the lower dose of Zn (200 ppm). Also, (Mady, 2009) reported that Zn treatments greatly increased contents of Auxins and cytokinins in faba bean plants while contents of ABA were decreased.

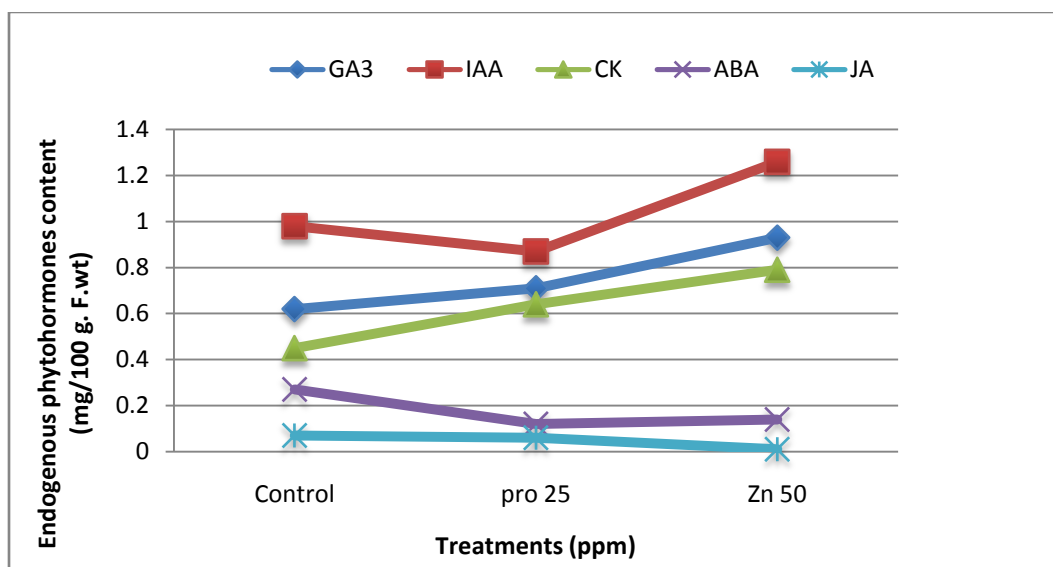


Figure 19. Effect of proline and zinc on endogenous phytohormones (mg/100g.fresh weight) of (*Chenopodium quinoa*) plants.

## 7. Mineral elements

In our study, it had been found (figure 20) that mineral element contents in seeds ( $N^+$ ; 13.86%,  $P^{+3}$ ; 43.48%,  $K^+$ ; 18.81%) of quinoa plants were markedly considerably elevated as a result of the remedies with Pro. Treatment with proline resulted in; increases in the mineral elements contents. The effect of proline as regards the mineral elements contents were recorded by other investigators, Abo Sedera *et al.* (2010) revealed that spraying strawberry plants with amino acids significantly increased total nitrogen, phosphorus and potassium in plant foliage compared to the untreated control.

In the present investigation, it was found that, treatment with Zinc resulted in; increases in mineral elements contents ( $N^+$ ; 20.48%,  $P^{+3}$ ; 169.57%,  $K^+$ ; 14.85%). The potent variable effect of Zn on the mineral elements contents was recorded by other investigators. In this respect, Eid *et al.* (2010) indicated that treatments of Zn significantly increased all nutrients in leaves, i.e.  $N^+$ ,  $P^{+3}$ ,  $K^+$ , as compared with the control treatment in (*Polianthes tuberosa*). Akay (2011) found that content of phosphorus significantly increase in response to treatment of Zn in three types of chickpeas

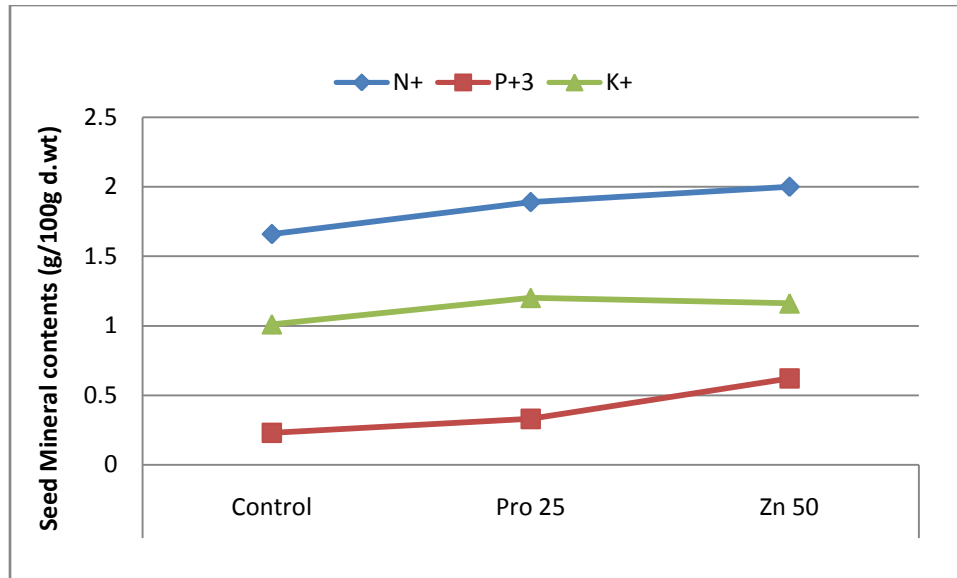


Figure 20. Effect of proline and zinc on mineral contents (g/100g d.wt) of (*Chenopodium quinoa*) plants.

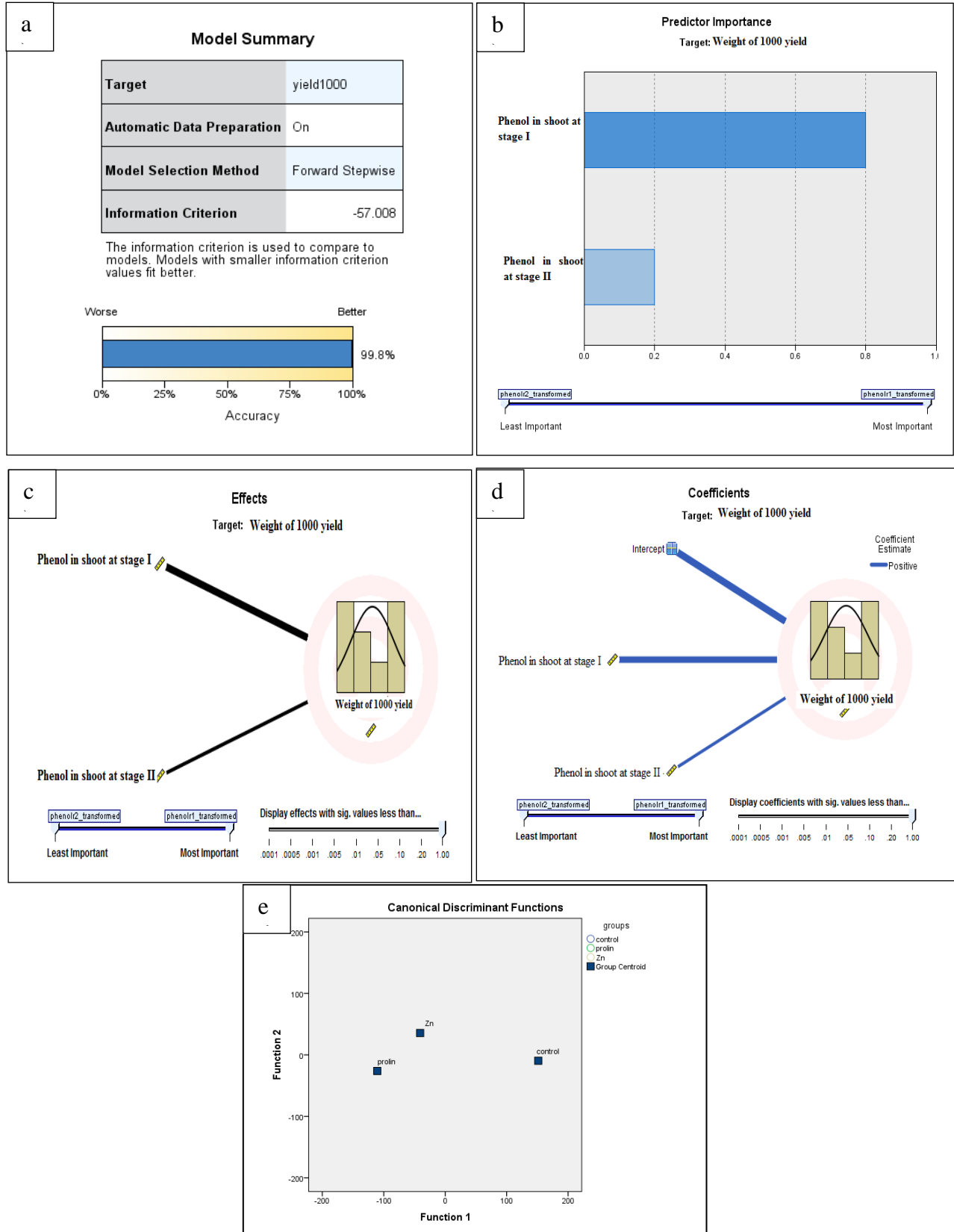
### 8. Automatic linear modeling and discriminant analysis

Finally, when we used the yielded weight as a target we observed that the accuracy of all data about 99.8%. The effect of target weight of 1000 seed the wide line is very effect as total phenol in shoot stage I then total phenol in shoot stage II, also the coefficient of target yield weight the blue color wide line is effect as total phenol in shoot stage I then total phenol in shoot stage II showed in figure (21) (a:d).

So, we make discriminant analysis that led to conclusion when use different treatments of Proline 25 ppm, zinc 50 ppm in foliar application on quinoa plants ,we resulted that the Zinc 50 ppm then proline 25 ppm as in figure (21) (e).

### Conclusion

From the preceding results and discussion, it can be concluded that foliar application of quinoa plants with proline at 25 ppm and zinc at 50 ppm, individually at elongation stage, stimulate the growth of quinoa plants via the enhancement of the biosynthesis of photosynthetic pigments; improved yield by increasing seed yield/plant (seeds index) and also increased contents of carbohydrate, proteins and phenols, endogenous phytohormones and mineral of quinoa plants and thus all last treatments improved quinoa seed quality and nutritional value. zinc at 50 ppm then proline at 25 ppm were greatly effective in improving and sometimes maximizing the growth and yield of quinoa plants.



Figures 21. show model summary from (a-d) and discriminant of yield target at (e)

## References

- Abd El-Samad, H. M.; Shaddad, M. A. K. and Barakat, N.(2010):** The role of amino acids in improvement in salt tolerance of crop plants. *Journal of Stress Physiology & Biochemistry*, Vol. 6 No. 3.
- Abo Sedera, F.A.; Abd El-Latif, A.A.; Bader, L.A.A. and Rezk, S.M.(2010):** Effect of NPK mineral fertilizer levels and foliar application with humic and amino acids on yield and quality of strawberry. *Egypt0. J. Appl Sci.*; 25:154-169.
- Ahamed, N.T.;Singhal, R. S.; Kulkarni, P. R. and Pal, M.A. (1998):** Lesser-known grain, *Chenopodium quinoa*: Review of the chemical composition of its edible parts. *Food and Nutr Bull.*, 19: 61-70.
- Ahmed, A.M.; Talaat, I.M. and Khattab, H. I. (2014):** Changes in growth, hormones levels and essential oil content of *Ammi visnaga* L. plants treated with some bioregulators. *Saudi J. Biol. Sci.* V.21(4); 355-365.
- Akay, A.(2011):** Effect of zinc fertilizer applications on yield and element contents of some registered chickpeas varieties. *African Journal of Biotechnology* Vol. 10:12890-12896.
- Chapman, H. D. and Pratt, P. F. (1978):** *Methods of Analysis for Soils, Plant and Water*, 50: 309.Univ. Calif., Dept. Agric. Sci., Priced Publication, 4034, USA.
- Daniel, H.D. and George, C.M. (1972):** Peach seed dormancy in relation to endogenous inhibitors and applied growth substances. *J. Amer. Soc. Hort. Sci.* 97:651-654.
- De Bruin, A. (1964):** Investigation of the food value of quinoa and canihua. *J. Food Sci.*, 29: 872.
- Doweidar, M. M. and Kamel, A.S. (2011):** Using of quinoa for production of some bakery products (glutenfree).*Egyptian J. of Nutrition.* (2): 21-52.
- Duffy, B. (2007):** Zinc and plant disease. In: *Mineral nutrition and plant disease*, L. E. Datnoff, W.H.elmer, and D.m. Huber, Eds., 155-175.
- Eid, R. A. ; Khalifa, R. Kh. M. and Shaaban, S.H.A. (2010):** Effect of foliar application of zinc and bezyladenine on growth, yield and chemical constituents of Tuberose Plants. *Research Jour. Of Agri. And Biolo. Sci.* 6:732-734.
- EL-Sherbeny, M.R. and Da Silva, T.J.A. (2013):** Foliar treatment with proline and tyrosine affect the growth and yield of beet root and some pigments in beetroot leaves. *Journal of Horticultural Research*, vol. 21(2): 95-99.
- Fageria, N.K. and Baligar, V.C. (2005):** Growth components and zinc recovery efficiency of upland rice genotypes. *Pesq. Agropec. Bras.* 40: 1211-1215.
- FAO, (2011):** Quinoa: An ancient crop to contribute to world food security. Regional Office for Latin America and the Caribbean.
- Fouda, H.M. (2013):** The physiological responses of spermidine and arginine to *Helianthus tuberosus* L. under salt stress. M.SC. Thesis, Bot. Dep., Fac. Sci., Al -Azhar Univ., Cairo, Egypt.
- Gamal El-Din, K.M. and Abd El-Wahed, M.S.A., (2005):** Effect of some amino acids on growth and essential oil content of chamomile plant. *Inter. J. of Agric. Biol.*, 7, 376-380.
- Härdle, W. and Simar, L. (2007):** *Applied Multivariate Statistical Analysis*. 2nd ed, Springer, 420pp.
- Khan, A.J.I.; Iftikhar, A.; Humera, N. and Maria, N. (2014):** Role of proline to induce salinity tolerance in sunflower (*Helianthus annus* L). *Sci. Tech. and Dev.* 33 (2): 88-93.

**Khudsar, T.; Mahmood, Z.; Iqbal and Sairam, R. K. (2004):** Zinc-induced changes in morpho-physiological and biochemical parameters in *Artemisia annua*. *Biologia Plantarum*, 48(2): 255-260.

**Knegt, E. and Brunima, J. (1973):** Rapid sensitive and accurate determination of indole-3-acetic acid. *Phytochem.* 12: 573-576.

**Lowery, O. H.; Rosebrough, N. J.; Farr, A. L. and Randall, R. J. (1951):** Protein measurement with the folin reagent. *J. Biol.Chem.*193:265-275.

**Mady, M. A.(2009):** Effect of foliar application with yeast extract and zinc on fruit setting and yield of faba bean (*vicia faba* L). *J. Biol. Chem. Environ. Sci.*, 2009,Vol. 4(2): 109-127.

**Mousavi, S.R.; Galavi, M. and Rezaei, M. (2012):** The interaction of zinc with other elements in plants. *Intl. J. Agri. Crop. Sci.* Vol., 4 (24), 1881-1884.

**Mugo, S.; De Groote, H.; Bergvinson, D.; Mulaa, M.; Songa, J. and Gichuki, S. (2005):** Developing at maize for resource-poor farmers – recent advances in the IRMA project. *African J.Biotec.*, 4: 1490–1504.

**Perveen, R.; Qasim, A.; Farooq, A.; Muhammad, A. and Nazamid, S. (2013):** Ameliorating Effects of Exogenously Applied Proline on Seed Composition, Seed Oil Quality and Oil Antioxidant Activity of Maize (*Zea mays* L.) under Drought Stress. *Int. J. Mol. Sci.*, 14, 818-835.

**Reda, F.; Abdelhamid, M.T. and El-Lethy, S.R.(2014):** The Role of Zn and B for Improving *Vicia faba* L. Tolerance to Salinity Stress. *Middle East J. Agric. Research*, 3(4): 707-714.

**Samreen, T.; Humaira Hamid U.S.; Saleem U. and Muhammad, J. (2013):** Zinc effect on growth rate, chlorophyll, protein and mineral contents of hydroponically grown mung beans plant (*Vigna radiata*). *Arabian J. Chem.*,

**Seilsepour, M. (2006):** Study of zinc effects on quantitative and qualitative traits of winter wheat in saline soil condition. *Desert . J.* 11(2): 17-23.

**Shahid, M.A.; Rashad, M.B.; Pervez, M.S.; Tahira, A.; Aqeel, M.A.; Javaid, M.M. and Garcia- Sanchez, F.(2014):** Exogenous proline and proline-enriched *Lolium perenne* leaf extract protects against phytotoxic effects of nickel and salinity in *Pisum sativum* by altering polyamine metabolism in leaves *Turk .J. Bot* , 38: 914-926.

**Snedecor, G. M. and Cochran, W. G. (1989):** Statistical methods-7th edition, Iowa state Univ., Press, Ames., Iowa, USA., pp. 325-330.

**Sofy, M.R. (2009):** Physiological and biochemical studies on the effect of certain growth regulators and mineral nutrients on some plants. M.Sc. Thesis, Bot. Dep., Fac. Sci., Al-Azhar Univ., Cairo, Egypt.

**Szabados, L. and Savoure, A. (2009):** Proline: a multifunctional amino acid. *Trends in Plant Science* 15, 89–97.

**Tajlil, A.H.; Alireza,P. and Davood, E.A. (2014):** Effects of seed priming by mannitol and zinc sulfate on biochemical parameters and seed germination of chickpea. *Intl J Farm & Alli Sci.* Vol., 3 (3): 294-298.

**Tobbal, Y.F.M. (2006):** Physiological studies on the effect of some nutrients and growth regulators on plant growth and metabolism. Ph. D. Thesis, Fac. Sci. Al-Azhar Univ.

**Umbriet, W. W.; Burris, R. H.; Stauffer, J. F.; Cohen, P. P.; Johsen, W. J.; Lee page, G. A.; Patter, V. R. and Schneicter, W. C. (1969):** Manometric techniques, manual describing methods applicable to the studs of tissue metabolism. Burgess publishing co., U.S.A; P.P.239.

**Vernon, L.P. and Selly, G.R. (1966):** The chlorophylls. Academic press. New York and London.

**Zaky, L.M.; Hassanein, R.A.; Dowidar, A.E. and El-Mashad, A.A. (1999):** Effect of foliar treatment with Boron and Zinc on physiological responses of cowpea (*Vigna sinensis* cv. Cream 7) II- Metabolic activities during growth and development. Egypt. J. Physiol. Sci., 23(3): 443-469.

**Zhao, Z.Q.; Zhu, Y.G. and Cai, Y.L. (2005):** Effect of Zinc on cadmium uptake by spring wheat (*Triticum aestivum* L.): long term hydroponic study and short time 109 Cd tracing study. J. Zhejiang Univ. Sci., 6A(7): 643-648.