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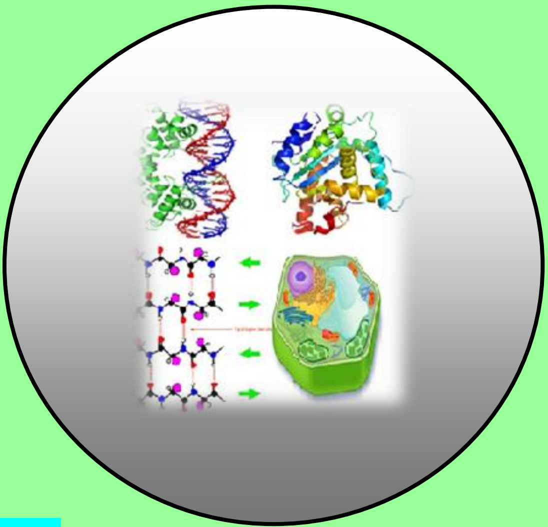

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RESEARCH PAPER

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Zinc Effect on Growth, Yield and Biomass Plant in Common Bean (*Phaseolus vulgaris* L.)

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ABSTRACT

In order to investigate Zn, foliar application effects on common bean yield and its components (number of pods per plant, number of seeds per pod and 100 seed weight and plant biomass), a field experiment was conducted at Al Azhar garden , Egypt during 2012 and 2013 growth season. The experiment was arranged in split plot of a randomized complete block design and replicated three times. Parameters measured were seed yield, number of pods per plant, number of seeds per pod and 100seed weight, contents of photosynthetic pigments, soluble carbohydrates, soluble proteins, total phenols and total prloine. Results showed significant effect of Zn treatment on seed yield, number of pods per plant ($p < 0.05$)and 100seed weight ($p < 0.01$). The time of foliar application on number of pods per plant ($p < 0.05$) and 100 seeds weight ($p < 0.01$) was also significant. Also, these treatments caused significant increases in the contents of photosynthetic pigments, soluble carbohydrates, and soluble proteins. While significant increases in the contents of proline. This was the case under of three levels of irrigation. In general, the highest yield was produced by Zntreatment. There was a significantand positive correlation between seed yield and its components.
Key words: Drought, Growth, Yield and Biomass, Phaseolus vulgaris, Zinc and Nutrition.

INTRODUCTION

Drought is one of the most significant manifestations of abiotic stress in plants mainly in arid and semi-arid areas and is usually associated with other stresses such as high temperature and irradiance. The predicted increase of dry days per year in many areas of the globe will further exacerbate this problem, especially in arid and semi-arid zones of the Mediterranean **(Luterbacher, 2006).** Drought reduces plant growth by affecting several physiological and biochemical processes, such as photo- synthesis, respiration, nutrient transport and hormone balance, leading to the reduction of fresh and dry biomass **(Lei *et al*., 2006; Farooq *et al*., 2012).** Plants can escape, avoid or tolerate drought stress according to the type of strategy adopted **(Harb *et a*l., 2010; Farooq *et al*., 2012).** Therefore, different mechanisms have been evolved to allow plants to adapt and survive for long periods of water deficit **(Cruz de Carvalho, 2008).** Desert plant species have developed different mechanisms to cope with extreme dry conditions, either by regulating their phenology choosing extremely short life cycles, or by osmotic adjustment **(Chaves *et al*., 2003; Bartels and Sunkar, 2005),** allowing cell enlargement and plant growth during severe drought stress by keeping the stomata partially open to allow CO2 assimilation **(Hare *et al.,* 1998).**

Common bean (*Phaseolus vulgaris* L.) is grown over a wide range of environments, including sites with low or high soil temperatures at sowing time. Bean plant is sensitive to chilling soil temperatures often encountered during early sowing. Early sown seeds that are subjected to chilling temperatures were smaller, suffered reductions in the rate of emergence and maximal emergence than late sowing **(Rodiño *et al*., 2006).**

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 soilsare capable of supplying adequate amounts for crop production, addition of zinc fertilizers is needed for others **Mousavi *et al*. (2012).**

MATERIALS AND METHODS

Uniform common bean seeds were planted in El-Behaira, Egypt on the date 6.4.2013 in three plots (3 m width and 15 m length for each plot) containing 24 ridges for each plot. The seeds were sown on one side of the ridge, with 20 cm apart between the hills. The developed plants were irrigated whenever required with tap water until the complete germination. Irrigation was done seedlings when the ages of seedlings are 17 days by using three different level of irrigation (10, 15, 20 days).

Irrigation types:

- First level (after 10 days tap water)
- Second level (after 15 days tap water)
- Third level (after 20 days tap water)

Combined treatments

Zn (10 days irrigation water + 50 ppm zinc sulphat).

Zn (15 days irrigation water + 50 ppm zinc sulphat).

Zn (20 days irrigation water + 50 ppm zinc sulphat).

The plants of common bean were treated twice with the above mentioned treatments (as foliage spraying). The first treatment was made when the age of plants was 33 days, while the second treatment was made when the age of plants was 70 days of sowing. The plant samples were collected for analysis when the plants were 45 (Stage I) and 85 (Stage II) days old. At the end of the growth season (149 days), analysis of the seeds yielded from the different treatments as well as the control was done.

The physical and chemical properties of the soil are present in **Tables 1 and 2**

Table1.Physical properties of the used soil land.

Gravels	Fine gravels	Coarse Sand	Medium sand	Fine sand	silt	Clay	Textureclass
1.3	4	5	45	23	7.5	17	Sandy-clay soil

Table 2.Chemical properties of the used soil.

TSS Ppm	pH	E.C. mmhos/cm	Cationsmeq/L				Anion meq/L			
658	7.2	2	Na+	K+	Ca++	Mg++	Cl-	SO4--	HCO3-	CO3--
			1.85	0.5	2.58	1	2.64	1	1	Zero

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.

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 proline were estimated according to the method of **Bates *et al*., (1973).**

Statistical methods

All statistical calculations were done using computer programs. Microsoft excels 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).**

RESULTS AND DISCUSSION

Growth and Yield Responses

Results of the present work **Figs (1, 2 & 3**) showed that, throughout the different stages of growth, shoot length's, number, Fresh and dry weights of shoot and roots, Number of pods, Number of seeds / plant and 100-seed weight of leaves were significantly affected in plants in response to the different irrigation interval. The magnitude of reduction increased by increasing irrigated water days

In **Fig (1)** revealed also that, at first level of irrigation treating common bean plants with Zn. resulted in significant increases in shoot length specially at second stage of growth. Also, the same results are obtained with second level of irrigation. At the third level of irrigation, shoot lengths of Zn-treated plant were significantly increased than that of control, this was the case at the second stage of growth.

Also in **Fig (2)** shows that, at the three level of irrigation, in significant response in root lengths of common bean plant were resulted. This was the case at the two stage of growth.
The obtained results **Fig (2)** revealed, also that treating common bean plants with Zn resulted in mostly, significant increase in root length's. This was valid at the two stage of growth, and at three levels of irrigation.
On the other hand, results in **Fig (3)** revealed that, at the first level of irrigation, treating common bean plants with Zn resulted in, significant decreases in number of leave's per plant. This was the case throughout the two stages of growth.
The obtained results **Figs (4 & 5) and Figs (6 & 7)** revealed that, at the first level of irrigation treatment with Zn mostly significantly increased of roots were significantly both fresh and dry weights of shoot and roots of the treated plants. This was the case throughout the two stages of growth.
Under all applied levels of irrigation, it was found.
Fig (8) that treatment with Zn resulted in enhancing the Number of pods, Number of seeds / plant and 100-seed weight.
These results are in good agreement with those reported by others investigators, **Abd El–Wahed *et al*., (2006)** on maize, **Yildirim *et al.* (2008)** on cucumber and **El Tayeb & Ahmed (2010)** on wheat. Many studies have shown that biomass partitioning between roots and shoots is strongly influenced by the most limiting resource under stress growth conditions, and resource deficiency is often ameliorated by increasing the biomass allocation to the part of the plant responsible for acquiring the most limiting resource (**Jamil, *et al.,* 2006**).
The obtained results revealed that application of Zn created significant stimulative effects on growth parameters of common bean plants. These effects were clear with the resulted induced increases in shoots lengths; number of leaves/plant, fresh and dry weight of shoots and decreases in root length when compared to unsprayed plant. (**Zhang *et al.* 2012**).

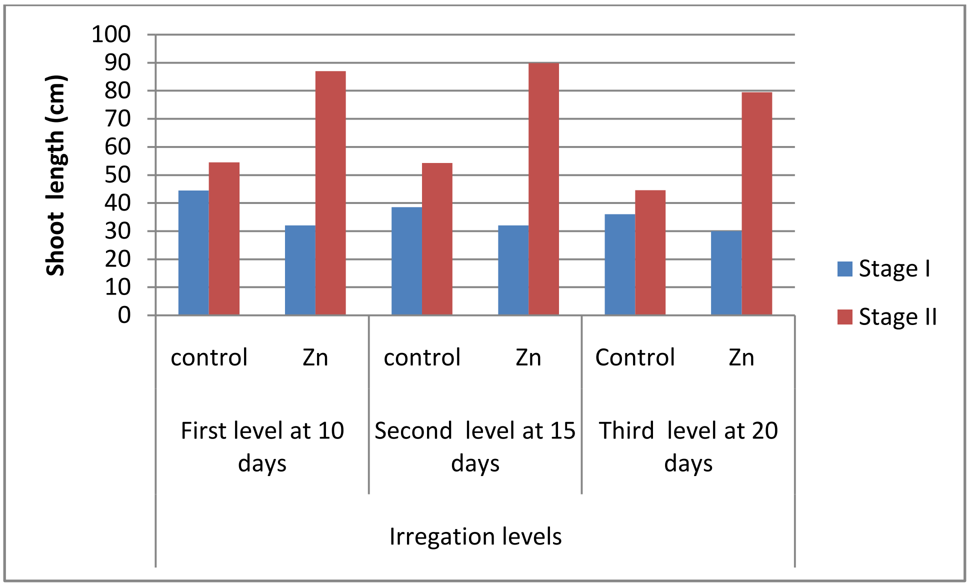

Figure 1. Effect of zinc on shoot length / plant of (*Phaseolus vulgaris* L.) plants.

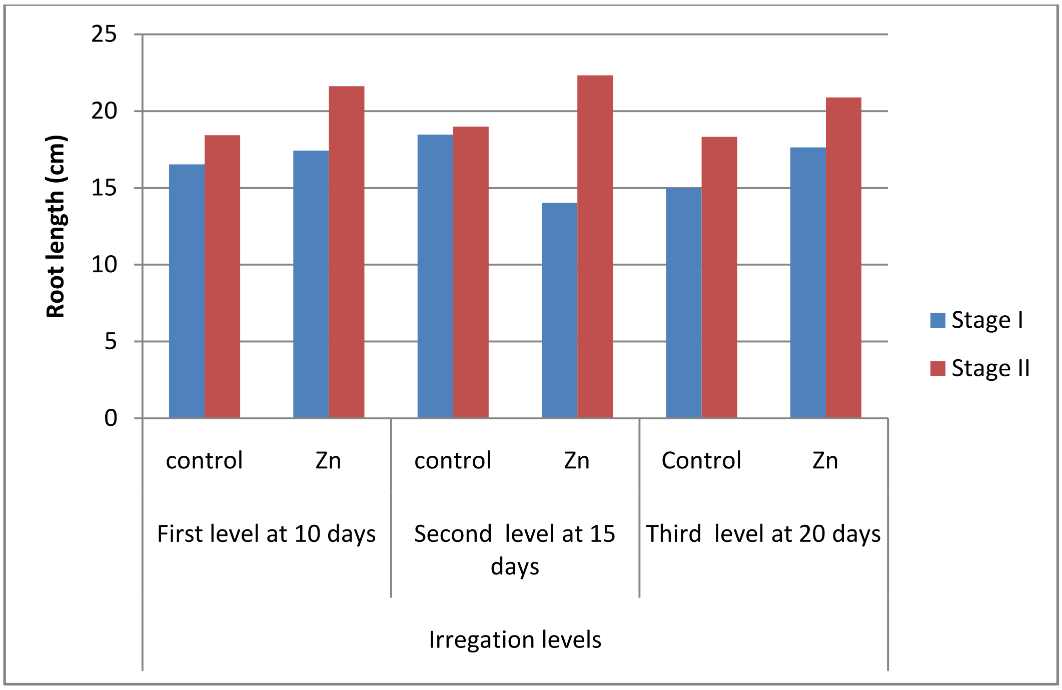

Figure 2. Effect of zinc on root length / plant of (*Phaseolus vulgaris* L.) plants.

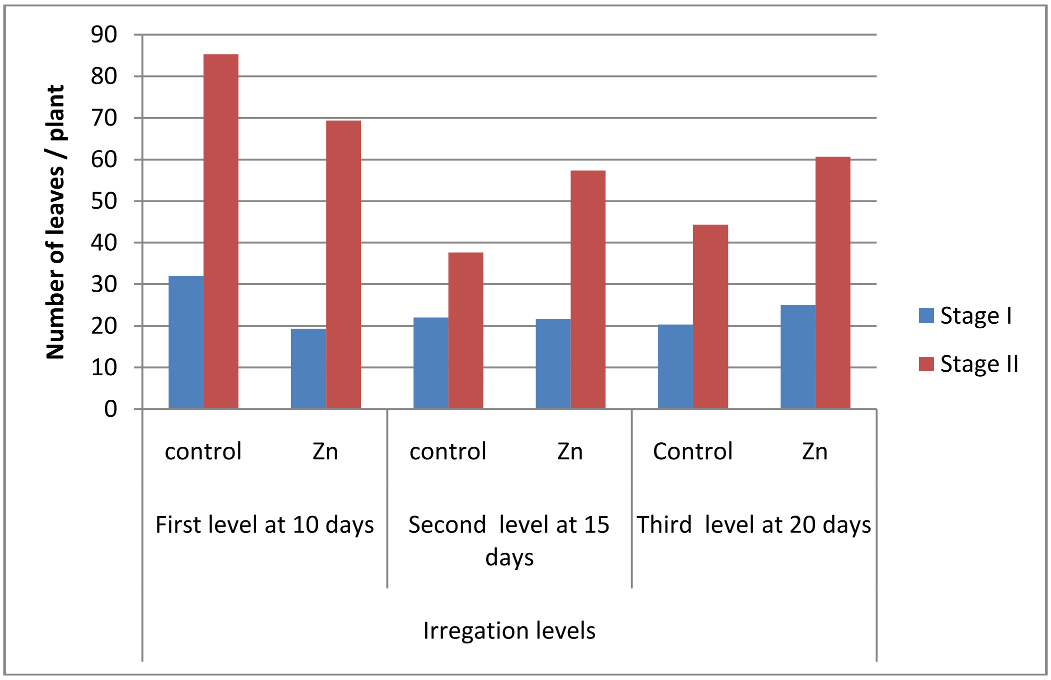

Figure 3. Effect of zinc on number of leaves / plant of (*Phaseolus vulgaris* L.) plants.

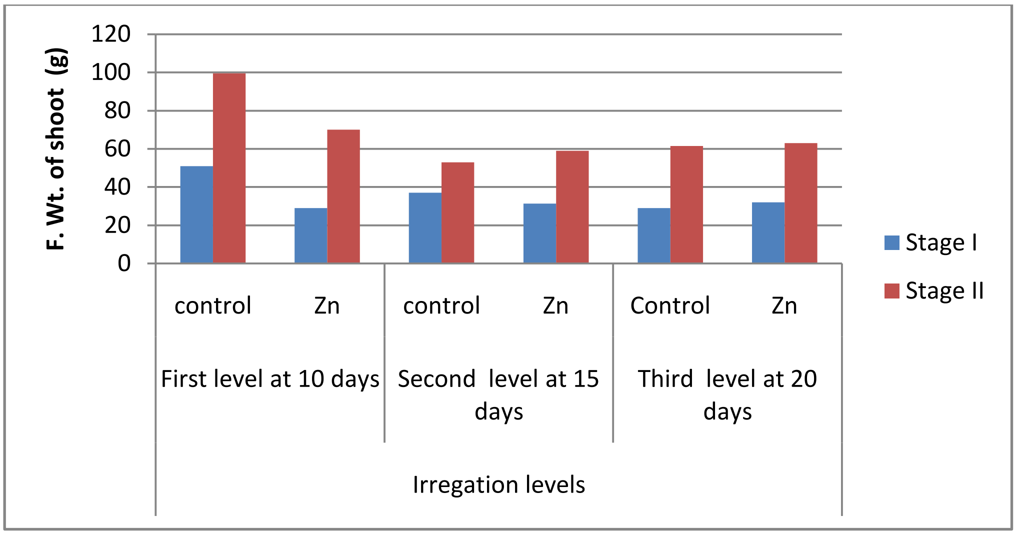

Figure 4. Effect of zinc on fresh weights of shoot of (*Phaseolus vulgaris* L.) plants.

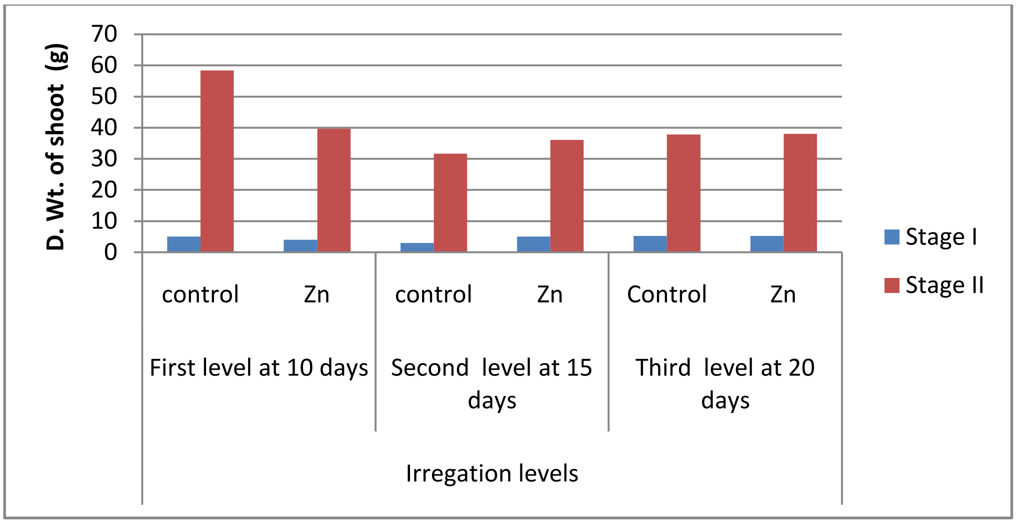

Figure 5. Effect of zinc on dry weights of shoot of (*Phaseolus vulgaris* L.) plants

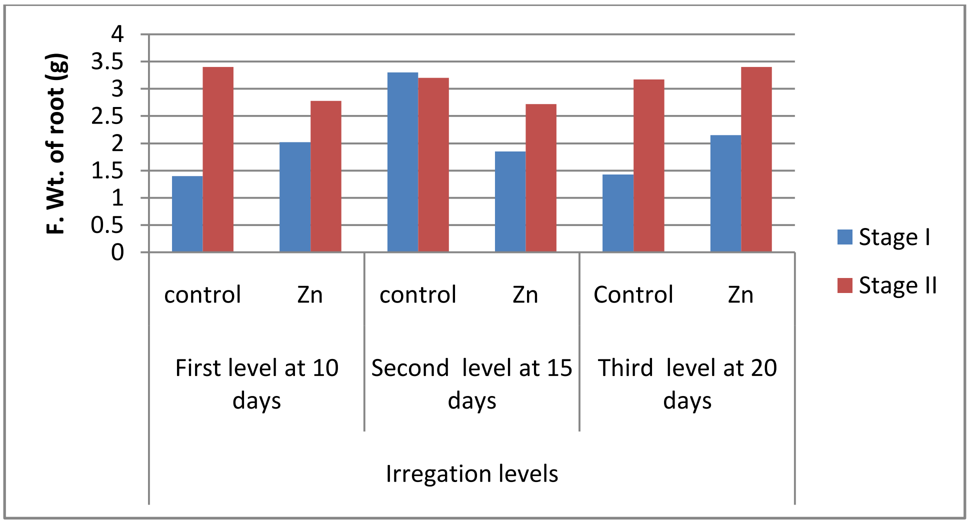

Figure 6. Effect of zinc on fresh weights of root of (*Phaseolus vulgaris* L.) plants.

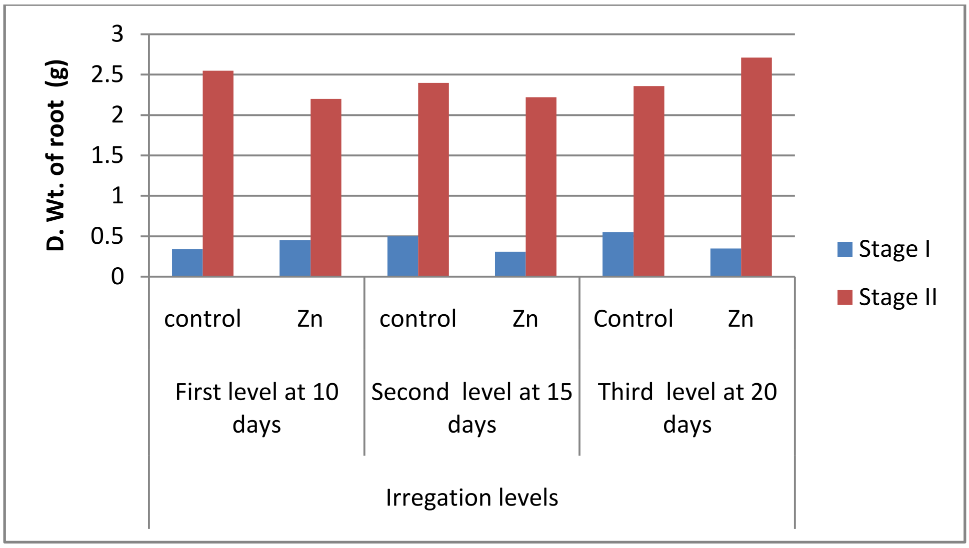

Figure7.Effect of zinc on dry weights of root of (*Phaseolus vulgaris* L.) plants.

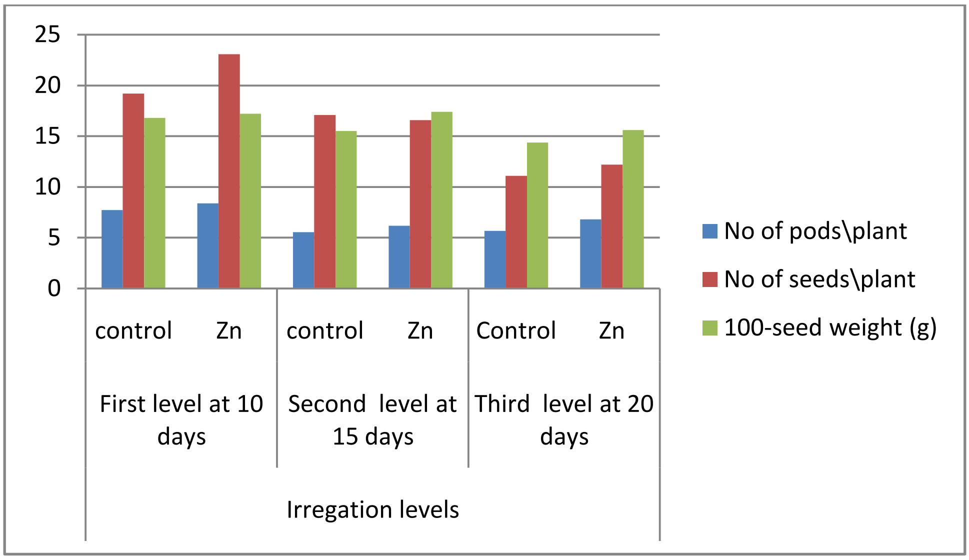

Figure8.Effect of zinc on the Number of pods, Number of seeds / plant and 100-seed weight of (*Phaseolus vulgaris* L.) plants.

Photosynthetic Pigments

A) chlorophyll content

Results of the present work **Figs (9 and 10)** revealed that, contents of chlorophylls (a, b & total) were, mostly, highly significantly decreased in the second and third levels of irrigation. This was the case throughout the two stages of growth.

Results in **Figs (9 and 10)** clearly revealed that, the contents of chlorophyll (a), (b) as well as total chlorophyll (a + b) all were increased in response to the application of Zn. This was the case throughout the two stages of growth. The statistical analysis of the obtained results showed that, most of such increases were significant. This was the case in plant grown under the first level of irrigation. **Manivannan *et al.* (2007)** reported that drought stress significantly decreased the Chl *a*, *b* and total Chl contents in sunflower.

The Chl content has a close negative correlation with water stress; thus, Chl measurements can be a useful index in determining the stress intensity **(Shen *et al.* 2008).**

B) Carotenoids contents

In **Fig (11)** revealed that, the contents of carotenoids were gradually with increasing the irrigation interval level. Statically the observed increases were found to be highly significant in plants grown at the third level of irrigation. This was the case throughout the duration of the experiment.

In **Fig (11)** revealed that, contents of carotenoids were mostly significantly increased in response to the treatments with Zn. This was the case in all levels of irrigation and throughout the duration of the experiment.

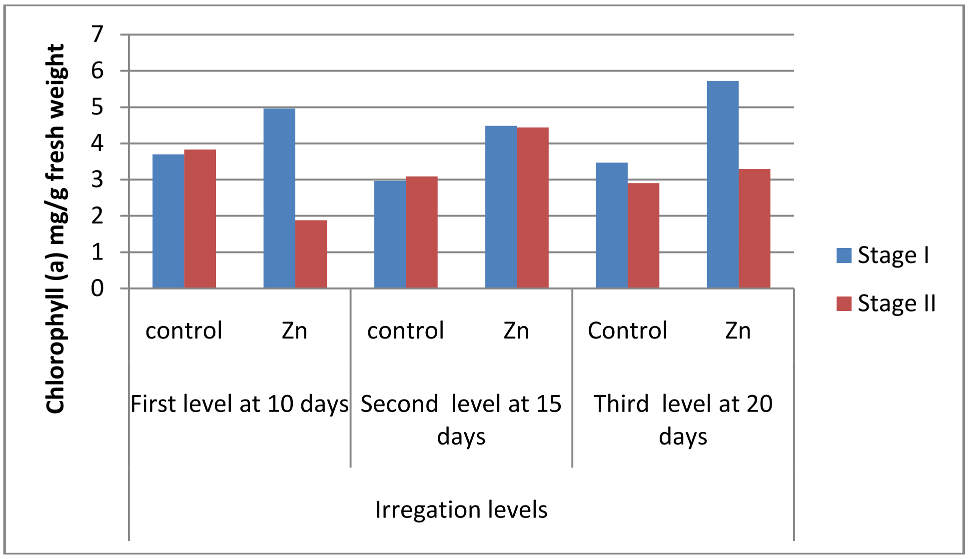

Figure 9. Effect of zinc on contents of chlorophylla of fresh of (*Phaseolus vulgaris* L.) plants.

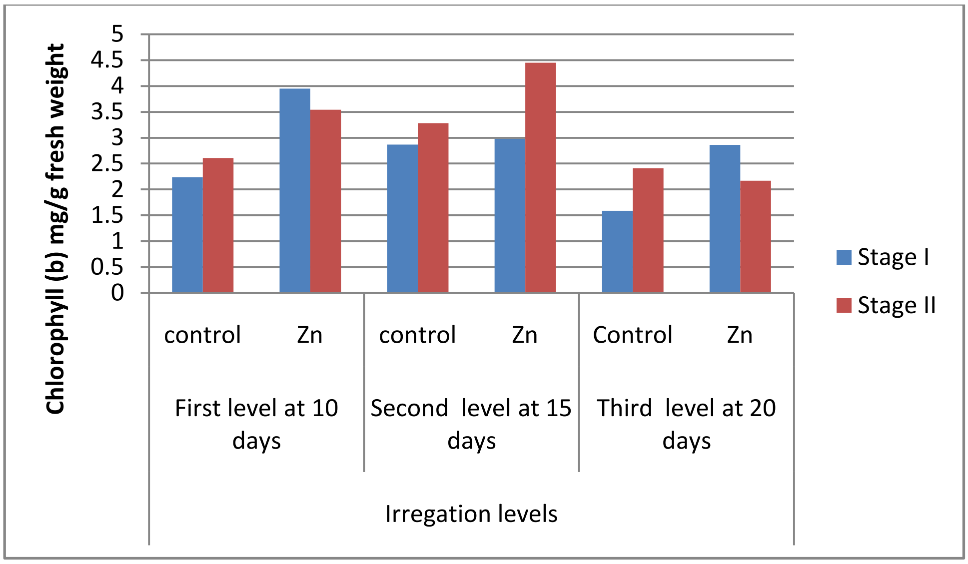

Figure 10. Effect of zinc on contents of chlorophyllbof fresh of (*Phaseolus vulgaris* L.) plants.

The increase in stomatal aperture following foliar application of Zn and B is thought to result from the effects of these elements in maintaining membrane integrity (**Khan *et al.,* 2004; Cakmak *et al.,* 1995; Marschner, 1995).** The studies with foliar applications of Zn have revealed a positive effect on photosynthesis rate and plant growth under drought stress (**Kastori *et al.,*2000; Wei *et al.,* 2005).**

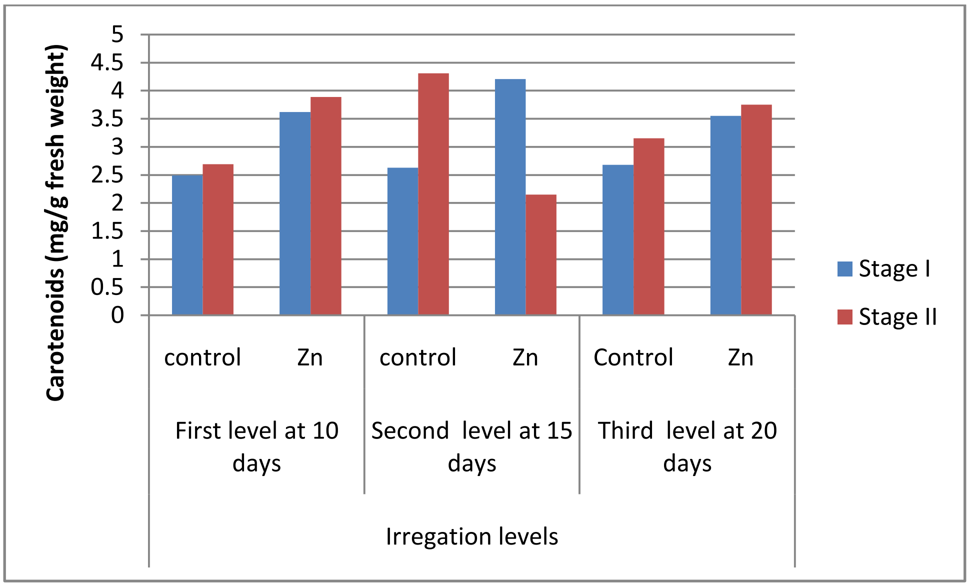

Figure 11. Effect of zinc on the contents of carotenoids of (*Phaseolus vulgaris* L.) plants.

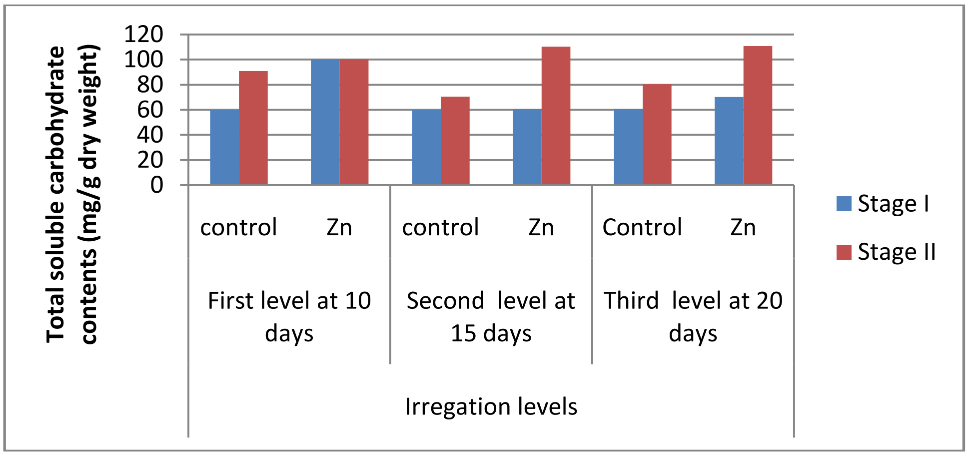

Figure 12. Effect of zinc on the contents of total soluble carbohydrates in the two stages in shoots of (*Phaseolus vulgaris* L.) plants.

Soluble Carbohydrates

Shoots and yield

Results in the present work **Fig (12)** recorded decreases in the contents of total soluble carbohydrates in the two stages in shoots and as well as in the yielded seeds in common bean plant growth under the second and third level of irrigation.

Contents of total soluble carbohydrates in seeds of common bean plants, mostly, highly significantly increased in response to the treatment with of Zn. This was the case in plants grown under the all applied irrigation interval levels **Fig (13)**.

The accumulation of soluble sugar in stressed plants has been widely reported as a response to salinity (**Gill *et al.,* 2001; Murakeozy *et al.,* 2003; Juan *et al.,* 2005 and Lacerda *et al.,* 2005**). Salt stress increase soluble carbohydrates in plant **Kong *et al.* (2014)**, he reported that salicylic acid treatment might also, assumed to inhibit polysaccharide hydrolyzing enzyme system on one hand and / or accelerate the incorporation of soluble sugar into polysaccharides.

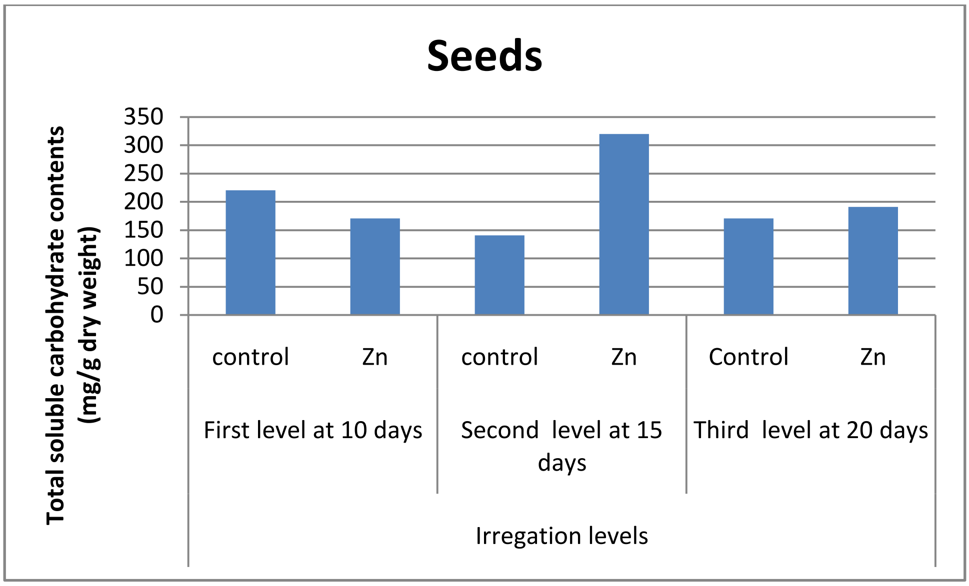

Figure 13. Effect of zinc on the contents of total soluble carbohydrates in the two stages in shoots of seeds of (*Phaseolus vulgaris* L.) plants.

Soluble Proteins

Results of the present work **Figs (14 and 15)** revealed that, mostly, highly significant increases in the contents of soluble proteins in shoots and roots of common bean were resulted in plants grown under the second and third level of irrigation. This was the case throughout the two stages of growth. Highly significant decrease in soluble protein contents in yielded seeds was observed in response to the aforementioned treatment.

On the other hand, the obtained results **Figs (14 and 15)**. revealed that, treating common bean with Zn at the first level of irrigation, resulted in, mostly, highly significant increases in the contents of soluble proteins in shoots, seeds as well as in the yielded seeds of the treated plants.

(**Jaleel *et al.,* 2008**), showed that the total soluble protein decreased significantly in shoots roots and yielded with increasing of different sea water level. In *phyllanthus amarus* plants, NaCl reduced the protein content these results were in agreement with **Azooz *et al.* (2004)** in sorghum and **Lobato *et al.* (2008)** in *Vigna unguiculata*.

Shirani Rad (2012) reported that the normal irrigation and Zn consumption of 15 ton ha-1 produced the highest protein contents.

The accumulation of osmolyte compounds such as sugars and amino acids, in the cells as a result of water stress is often associated with a possible mechanism for tolerating the harmful effects of water shortage **(Pirzad *et al.* 2011).** Also found that yield increased similar results have been reported by **Thalooth *et al.* (2006), Maman *et al.* (1999), Babnik *et al* .(2002) and Cox and Cherney (2005).**

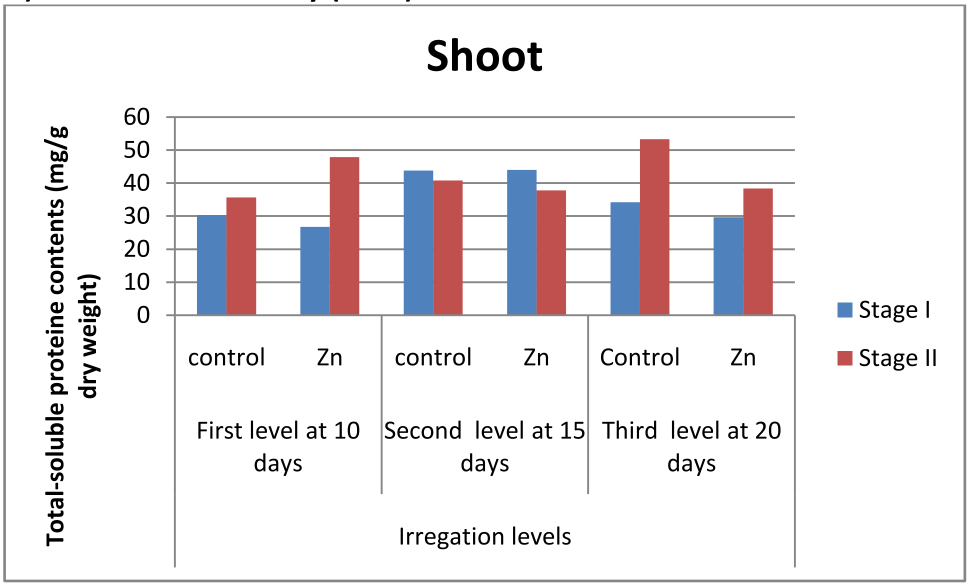

Figure 14. Effect of zinc on the contents of total soluble proteins in shoot of (*Phaseolus vulgaris* L.) plants.

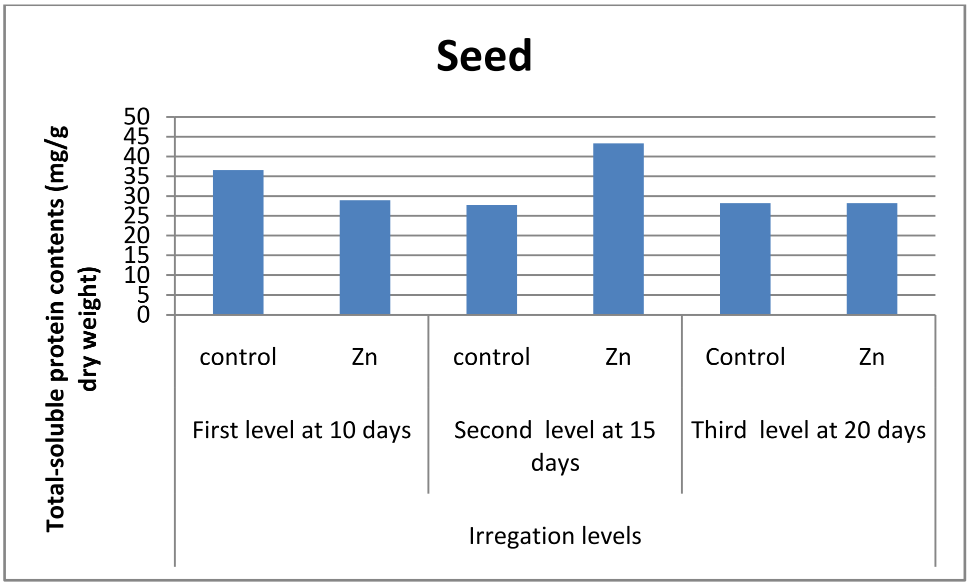

Figure 15. Effect of zinc on the contents of total soluble proteins in seeds of (*Phaseolus vulgaris* L.) plants.

Total proline

Results of the present work **Fig (16)** revealed that, contents of proline in shoots as well as in the yielded seeds were gradually significantly increased in the plants irrigated every 20 day when belong compared with those grown under the first level of irrigation. The similar results have been reported by **Moslemi *et al.* (2011).**

Fig (16) showed that, treating common bean plants with Zn, under the first & second levels of irrigation, resulted in, mostly, highly significant increases in the contents of proline in all analyzed parts (shoots) of the treated plants. This was the case in plants grown at two stages.

In organisms ranging from bacteria to higher plants, there is strong correlation between increased cellular proline levels and the capacity to survive under stress. In addition to its role as an osmolyte for osmotic adjustment, proline contributes to stabilizing sub cellular structure (membrane and proteins) scavenging free radicals and buffering cellular redox potential under stress conditions **(Ashraf and Foolad, 2007).**

The combined application of Zn decreased the proline accumulation rates to 44.35 and 34.42%, respectively, compared with the interval water. **Md. Rezaul Karim *et al* (2012).**

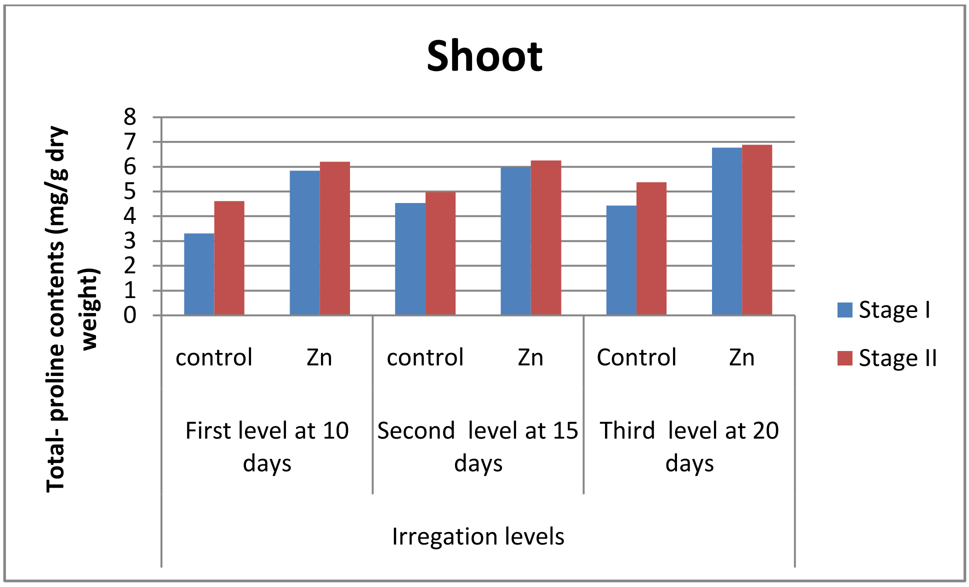

Figure16.Effect of zinc on the contents of proline in shoots of (*Phaseolus vulgaris* L.) plants.

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