



Effect of irrigation and application of Zn fertilizer on seed storage proteins of chickpea (*Cice arietinum* L.)

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ABSTRACT

This study was performed in order to evaluate the effects of irrigation and application of Zn fertilizer on seed storage proteins in chickpea, Azad cultivar. Experiment was performed in an factorial using randomized complete block design with three replications. In this experiment, two factor consist of irrigation in three levels (I_1 = non irrigation and I_2 = irrigation in flowering stage), Zn fertilizer in six levels ($Zn_1=0$, $Zn_2=15\text{kg/ha}$, $Zn_3=25\text{kg/ha}$, $Zn_4=35\text{kg/ha}$, $Zn_5=55\text{kg/ha}$ and $Zn_6=65\text{kg/ha}$) was studied. The results showed that the effect of irrigation on seed storage proteins and protein yield was significant ($P<0.01$). Also results showed that effect of Zn fertilizer on seed storage proteins and protein yield was not significant. In non irrigation treatment seed storage proteins was increased compared to irrigation treatment and protein yield decreased. Also, results showed that no effects treatments (irrigation and Zn fertilizer) on protein banding patterns. Also, results indicated that not obvious any new band and not deleted any bands in all treatments.

Key words:Irrigation, protein and seed

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is one of the major pulse crops in the world with a total annual global production of 7.5 M tones from 10.3 M ha (FAO, 2003). It is cultivated on a large scale in arid and semiarid environments, and has considerable importance as food, feed and fodder. In recent years, grain legumes have played a primary role in the search for vegetable sources of proteins owing to the high protein content of the seed, ranging from 20% in pea to 40% in lupin (Cereletti, 1979). Chickpea seeds contain essential amino acids like isoleucine, leucine, lysine, phenylalanine and valine (Javid et al, 2004). The protein in chickpea is highly digestible (70-90%) (Sumera et al, 2009). The seed storage proteins are non enzymatic and have the sole purpose of providing proteins (nitrogen and sulphur source) required during germination and establishment of a new plant. Seed protein content and baking quality highly depend on genetic background and environmental factors, especially influence of drought and heat stress, during the grain filling period and nitrogen availability (Altenbach et al. 2002; Dupont and Altenbach 2003; Luo et al. 2000; Ottman et al. 2000; Rharrabti et al. 2001; Tea et al. 2004). In recent years, the applications of proteomic tools have become popular, and the tools are powerful methodologies for

detecting and examining changes in protein composition accurately (Singh et al, 1993). Storage protein is a method to investigate genetic variation and to classify plant varieties (Iqbal et al, 2005). Seed protein is not sensitive to environmental fluctuations; its banding pattern is very stable which advocated for cultivars identification purpose in crop. It has been widely suggested that such banding patterns could be important supplemental method for cultivars identification, particularly when there are legal disputes over the identity of a cultivar or when cultivars are to be patented (Singh et al, 1994). Seed storage protein is useful tool for studying genetic diversity of wild and cultivated rice (Singh et al, 1994). Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (SDS-PAGE) is most economical simple and extensively used biochemical technique for analysis of genetic structure of germplasm. As seed storage proteins are largely independent of environmental fluctuations, their profiling using SDS-PAGE technology is particularly considered as a consistent tool for economic characterization of germplasm (Javid et al., 2004; Iqbal et al., 2005). Accumulation of specific proteins and other compounds for nutrient storage to high levels is one of the characteristic events during seed development (Singh et al, 1993). Improvement of storage protein in seed is being given more and more attention all over the world (Kim et al., 1990). Protein is the performer of life activity, the change of plant morphology corresponds with the change of relative proteins (Singh et al, 1993). Despite the fact that the response of protein composition to environmental factors in mature wheat grain results from changes in protein deposition during plant development, very few studies has examined the effects of water stress and nitrogen fertilizer on protein profiling of grains (Iqbal et al, 2005). For gave to highest seed yield in agriculture addition to both nitrogen and phosphate fertilizer is very important (Shaban, 2013a,b). For gave the highest seed yield and protein yield in rapeseed (Kiani et al, 2013) and maize (Beyranvand et al, 2013) should apply both nitrogen and phosphate biofertilizers. Drought stress is the second important constraint of yield in chickpea after disease (Singh et al., 1994). Several studies have also shown that optimum yield can be obtained with irrigation at branching, flowering and pod formation stages (Prihar and Sandhu, 1968). Therefore this study was planned to examine effect of drought stress and N fertilizer on protein content and protein banding pattern of chickpea cultivars.

MATERIALS AND METHODS

Experimental design

A field experiment was conducted at Razi University of Kermanshah, Iran, on a clay soil. The experiment was laid out in a factorial design with three replications. In this experiment, two factor consist of irrigation in three levels (I_1 = non irrigation and I_2 = irrigation in flowering stage), Zn fertilizer in six levels ($Zn_1=0$, $Zn_2=15\text{kg/ha}$, $Zn_3=25\text{kg/ha}$, $Zn_4=35\text{kg/ha}$, $Zn_5=55\text{kg/ha}$ and $Zn_6=65\text{kg/ha}$) was studied. Plants The plots were fertilized with, P 2 O₅ at the rate of 60 kg/ha as basal application. The seeds were sown in rows on April 12, 2010. Each Azad cultivar of chickpea was planted in a 5m long, 6-row plot. Row to row and plant - plant distance was maintained at 25cm and 10cm, respectively. Seeds were placed at 3 cm depth in each row. The crop field was weeded twice to control weeds.

Seed protein and Electrophoresis

A single seed was grounded with a mortar and pestle and 10mg (0.01g) out of this seed flour was taken into a 1.5ml micro-tube. 400 μ l of the protein 10% glycerol, 5% β -mercaptoethanol, 5 M urea and 0.0001% bromo-phenol blue) was added and mixed well by vortexing. The crude homogenates were then centrifuged in micro-centrifuge machine at room temperature with 13000rpm for 20 min. The supernatant was separated and used for protein profiling. Protein concentration of extracts was measured by dye binding assay as described by Bradford (1976). Supernatant was mixed (4:1) with cracking solution (10 ml containing 1g SDS, 0.01g bromo-phenol blue, 2ml β -mercaptoethanol, 1.5ml 0.5M tris, pH 6.8, 5g sucrose and 6.5 ml water) on vortex mixer and heated in a boiling water bath for five minutes to denature the proteins. Proteins profiling of samples was performed using SDS- polyacryl amide gels as described by Laemmli (1970). Equal quantities of proteins (150 micro grams) from each sample along with protein

molecular weight marker were loaded into 10% gels. Electrophoresis was performed at constant voltage (100 volts). At end of electrophoresis, gels were dye in coomassie blue G-250 for 45 min. Then gel fixed in solution containing 10% Acetic acid and 40% Ethanol overnight, with constant agitation on a shaker. After fixing gel was washed with distilled water for 15 min, with changing the water after every 5 min.

Protein yield

Finally, amount of grain protein yield was accounted with follow (17):

$$\text{Grain Protein yield (kg/ha)} = \text{Grain protein percentage (\%)} \times \text{Grain yield (kg/ha)}$$

Statistical analysis

The statistical analyses to determine the individual and interactive effects of drought stress, N fertilization and cultivar were conducted using JMP 5.0.1.2 (SAS Institute Inc., 2002). Statistical significance was declared at $P \leq 0.05$ and $P \leq 0.01$. Treatment effects from the two runs of experiments followed a similar trend, and thus the data from the two independent runs were combined in the analysis.

RESULTS AND DISCUSSION

SDS-PAGE Protein Analysis

The seed storage proteins patterns Azad cultivar of chickpea under irrigation and Zn fertilizer after electrophoresis are shown in Figure 1. In total 28- 32 bands (since below 14kDa until over 78kDa molecular weight band) per treatments were detected in electrophoregrams. The SDS- PAGE results revealed that no effects treatments (irrigation and Zn fertilizer) on the protein banding patterns but in non irrigation treatment (1, 2, 3, 4, 5, and 6) columns were chromatic, because they have highest protein concentration (figure 1) compared to irrigation treatments (7, 8, 9, 10, 11, and 12) columns. In each level of Zn application all bands were similar that shows the protein was not affected by application of Zn fertilizer. These results were in agreement with the findings of Tanksley et al, 1981; Javid et al., 2004; Iqbal et al., 2005. However, this results indicated that not obvious any new band and not deleted any bands in all treatments. These findings were indicated that grain protein banding pattern is very stable and not sensitive to environmental changes and nutrition (Tanksley and Jones, 1981).

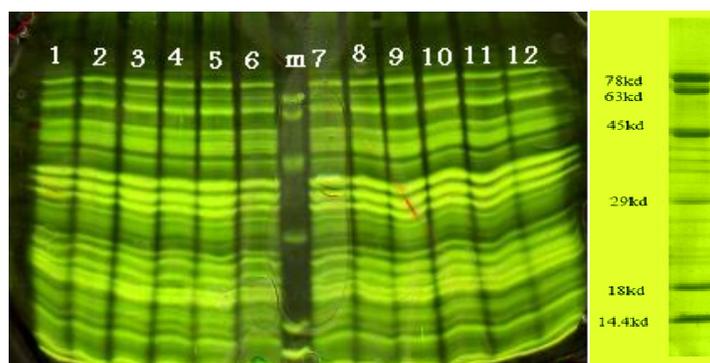


Figure 1. Protein banding patterns in chickpea under irrigation and application of Zn fertilizer

Column name from left to right:

1,2,3,4, 5, 6=Application of Zn fertilizer treatments in irrigation treatment with $Zn_1=0$, $Zn_2=15\text{kg/ha}$, $Zn_3=25\text{kg/ha}$, $Zn_4=35\text{kg/ha}$, $Zn_5=55\text{kg/ha}$ and $Zn_6=65\text{kg/ha}$ respectively.

m= Marker

7, 8, 9, 10, 11, 12,= Application of Zn fertilizer treatments in non irrigation treatment with $Zn_1=0$, $Zn_2=15\text{kg/ha}$, $Zn_3=25\text{kg/ha}$, $Zn_4=35\text{kg/ha}$, $Zn_5=55\text{kg/ha}$ and $Zn_6=65\text{kg/ha}$ respectively.

Seed storage proteins

The effect of irrigation treatment on seed protein was significant at 1% level. The comparison of the mean values of the seed protein showed that non irrigation treatment has the highest (1.72mg/ml) seed protein and the irrigation treatment has the lowest seed protein (1.11mg/ml) and the difference is significant. Among the Zn fertilizer treatments application of 55kg/ha treatment has the highest (1.51mg/ml) seed protein and the control treatment has the lowest seed protein (1.23mg/ml) and the difference is not significant. Similar results were reported by Kim et al., 1990; Suoyi Han et al, 2009.

Protein yield

The effect of irrigation and Zn fertilizer treatments on protein yield were significant at 1% level. The comparison of the mean values of the protein yield showed that irrigation treatment has the highest (421.5 kg ha⁻¹) protein yield and the non irrigation treatment has the lowest protein yield (221 kg ha⁻¹) and the difference is significant. Among the Zn fertilizer treatments, the highest protein yield (344.2 kg ha⁻¹) was belonged to the 55 kg ha⁻¹ treatment and the lowest protein yield (221 kg ha⁻¹) was belonged at control treatment and the difference was significant. These results were in agreement with the findings of Luo et al. 2000; Ottman et al. 2000; Rharrabti et al. 2001.

REFERENCES

- Altenbach SB, Kothari KM, Lieu D (2002) Environmental conditions during wheat grain development alters temporal regulation of major gluten protein genes. *Cereal Chem* 79:279– 285.
- Arshad M, Khalid A, Mahmood MH, Zahir ZA (2004) Potential of nitrogen and L-tryptophan enriched compost for improving growth and yield of hybrid maize. *Pak J Agric Sci* 41: 16-24.
- Beyranvand, H., Farnia, A., Nakhjavan, SH. and Shaban, M. 2013. Response of yield and yield components of maize (*Zea mayz* L.) to different bio fertilizers. *International journal of Advanced Biological and Biomedical Research*. Volume 1, Issue 9: 1068-1077.
- Bradford, M.M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. *Ann. Biochem.*, 72: 248-254.
- Cereletti, P. 1979. The Legume Proteins. *Proc. Congr. PPI*. 30 May -2 June, Perugia, Italy. pp. 31-57.
- Dupont FM, Altenbach SB (2003) Molecular and biochemical impacts of environmental factors on wheat grain development and protein synthesis. *J Cereal Sci* 38:133–146.
- FAO, 2003. *Production Year Book, 2002*. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy. <http://apps.fao.org>.
- Iqbal, S.H., A. Ghafoor and N. Ayub. (2005). Relationship between SDS-PAGE markers and Ascochyta blight in chickpea. *Pak. J. Bot.*, 37: 87-96.
- Isemura T., Shiyo N., Shigeyuki M., et al. (2001) Genetic variation and geographical distribution of Azuki bean (*Vigna angularis*) landraces based on the electrophoregram of seed storage proteins. *Breeding Sci.*, 51: 225-230.
- Javid, A., A. Ghafoor and R. Anwar. (2004). Seed storage protein electrophoresis in groundnut for evaluating genetic diversity. *Pak. J. Bot.*, 36: 87-96.

- Karim, M.F. and Q.A. Fattah, (2006). Changes in yield of chickpea biocomponents of chickpea (*Cicer arietinum* L.) sprayed with potassium naphthenate and naphthenicacetic acid. *Bangladesh J. Bot.*, 35(1): 39-43.
- Kiani, M, Farnia, A., and Shaban, M. (2013). Changes of seed yield, seed protein and seed oil in rapeseed (*Brassica napus* L.) under application of different bio fertilizers. *International journal of Advanced Biological and Biomedical Research*. Volume 1, Issue 10: 1170-1178.
- Kim CS, Kamiya S, Sato T, Utsumi S, Kito M (1990). Improvement of nutritional value and functional properties of soybean glycinin by protein engineering. *Protein Eng.* 3: 725-731.
- Laemmli, U.K. (1970). Cleavage of structure proteins assembly of the head of bacteriophage T4. *Nature*, 22: 680-685.
- Luo C, Branlard G, Griffin WB, McNeil DL (2000) The effect of nitrogen and sulphur fertilization and their interaction with genotype on wheat glutenins and quality parameters. *J Cereal Sci* 31: 185–194.
- Osborne, T. B., (1924) *The Vegetable Proteins*, Longmans Green, London, 1924.
- Ottman MJ, Doerge TA, Martin E (2000) Durum grain quality as affected by nitrogen fertilization near anthesis and irrigation during grain fill. *Agron J* 92: 1035–1041.
- Prihar SS, Sandhu BS (1968) *Irrigation of field crops*, Indian Council of Agric. Res New Delhi 142.
- Rharrabti Y, Villegas D, Garcia Del Moral LF, Aparicio N, Elhani S, Royo C (2001) Environmental and genetic determination of protein content and grain yield in durum wheat under Mediterranean conditions. *Plant Breed* 120:381–388.
- SAS Institute (2002) *JMP statistics and graphics guide*. SAS Institute Inc., Cary, NC.
- Shaban, M. (2013a). Application of seed equilibrium moisture curves in agro physics. *International journal of Advanced Biological and Biomedical Research*. Volume 1, Issue 9: 885-898.
- Shaban, M. (2013b). Biochemical aspects of protein changes in seed physiology and germination. *International journal of Advanced Biological and Biomedical Research*. Volume 1, Issue 8: 885-898.
- Singh KB, Malhotra RS, Halila MH, Knights EJ, Verma MM (1994) Current Status and Future Strategy in Breeding Chickpea for Resistance to Biotic and Abiotic Stresses, in *Expanding the Production and Use of Cool Season Food Legumes*, Eds. F.J. Muehlbauer and W.J. Kaiser, Kluwer Academic Pub., printed the Netherlands, p:572-591
- Singh, A.K., R.K. Chaudhry and R.P.R. Shaema, (1993). Effect of inoculation and fertilizer level on yield, nutrients uptake and economics of summer pulses. *Ind. J. Potassium Res.*, 9: 176-178.
- Sumera Iqbal and Asghari Bano.(2009). Water stress induced changes in antioxidant enzymes, membrane stability and seed protein profile of different wheat accessions. *African Journal of Biotechnology* Vol. 8 (23), pp. 6576-6587.
- Suoyi Han, Rui Fan, Tuanjie Zhao, Jingjing Yu and Deyue Yu.(2009). Seed storage protein components are associated with curled cotyledon phenotype in soybean. *African Journal of Biotechnology* Vol. 8 (22), pp. 6063-6067.

Tanksley S.D., Jones R.A. (1981) Application of alcohol dehydrogenase allozymes in testing the genetic purity of F1 hybrids of tomato. Hort. Sci., 16: 179-181.

Tea I, Genter T, Naulet N, Boyer V, Lummerzheim M, Kleiber D (2004) Effect of foliar sulfur and nitrogen fertilization on wheat storage protein composition and dough mixing properties. Cereal Chem 81: 759–766.

Thanh V.O.C., Hirata Y. (2002) Seed storage protein diversity of three rice species in the Mekong Delta. Biosphere Conservation, 4: 59-67.

Williams, P.C. and U. Singh, (1987). Nutritious quality and the evaluation of quality in breeding programmes. In: Chickpea (M.C. Saxena and K.B. Singh. Eds.). CAB International, UK. pp: 329-356.