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Original Research Article

Effect of Sowing Season and Zinc Sulfate Application Methods on Quantity and Quality Characteristics of *Cicer arietinum*

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ABSTRACT

Globally, low zinc in soils are widespread. In order to investigation of sowing season and zinc sulfate application by different methods and times on quantity and quality characteristics of chickpea, an experiment was conducted with factorial arrangement based on randomized complete block design in 3 replications. Zinc sulphate (ZS) involved 8 levels (control; ZS_0, soil application; ZS_s, foliar spray in early flowering; ZS_f, and foliar spray in early podding; ZS_p and their components as ZS_s ZS_f, ZS_s ZS_p, ZS_f ZS_p, ZS_s ZS_f ZS_p), with two planting seasons; F (fall), and S (spring). Soil application of Zinc sulfate was 25 kg ha^{-1} and foliar application of it was in concentration of 0.2: 1000. Results indicated that the effects of year, fertilizer treatments, planting dates and their interactions on yield were significant (*a*=1%). The maximum yield was obtained in treatment of F ZS_S ZS_f (soil application and one foliar spray of zinc sulfate in early flowering in fall sowing season) and treatment F ZS_s (soil application of zinc sulfate in fall sowing season) with yield of 1524 and 1522 kg ha^{-1}, respectively. Results indicated that application of zinc sulfate increased Zn uptake, grain yield and protein content by soil application at fall planting time. It was also sowed that in fall sowing season, an application of zinc sulfate in preplanting (25 kg ha^{-1}) and foliar spray in early flowering and in spring season, foliar spray in early flowering could be recommended.

Keywords: Micro-nutrients, Pulse crop, Rainfed, Spraying

Ekim Dönemi ve Çinko Sülfat Uygulama Methotlarının *Cicer arientum*'un Nitelik ve Nicelik Özellikleri Üzerindeki Etkisi

Topraklardaki düşük çinko dünya çapında yaygındır. Farklı yöntem ve zamanlamalar ile ekim dönemi ve çinko sülfat uygulamasının nohutun nitelik ve nicelik özellikleri üzerine etkilerini araştırmak amacıyla tesadüf blokları deneme deseni şeklinde 3 tekekerrürlü faktöriyel bir deneme kurulmuştur. Çinko sülfat (ZS) 8 aşamayı içermiştir (Kontrol; ZS_0, toprak uygulaması; ZS_s, erken çiçeklenmede yaprağa püskürtme; ZS_f, ve erken tomurcuklanmada yaprağa püskürtme; ZS_p ve bu grupların kombinasyonları ZS_s ZS_f, ZS_s ZS_p, ZS_f ZS_p, ZS_s ZS_f ZS_p), iki dikme mevsimi; F (sonbahar) ve S (ilkbahar). Çinko sülfatın toprak uygulaması 25 kg ha^{-1} ve yaprak uygulamasının konsantrasyonu 0.2;1000'dır. Sonuçlar; yılın, gübre uygulamalarının, ekim günlerinin ve bu grupların birbiriyle etkileşimlerinin üründeki etkisinin önemli olduğunu göstermiştir (*a*=1%). F ZS_S ZS_f uygulaması (toprak uygulaması ve sonbahar dikim sezonunda erken çiçeklenme döneminde çinko sülfatın tek yaprağa püskürtme) ve F ZSs uygulamasında (sonbahar ekim sezonunda çinko sülfatın toprak uygulaması) sırasıyla 1524 ve 1522 kg ha^{-1} maksimum ürün elde edilmiştir. Sonbahar ekim döneminde toprak uygulamasında Çinko sülfat uygulaması Zn alımını, tane verimini ve protein içeriğinin arttığını sonuçlarda gösterilmiştir. Ayrıca sonbahar ekim döneminde ekilmiş olan bitkilerde çinko sülfat uygulaması toprağa (25 kg ha^{-1}); erken çiçeklenme ve ilkbahar dönemlerinde yapraklara püskürtme yapılması önerilmiştir.

Anahtar kelimeler: Mikro besin elementleri, Baklagil, Yağmur, Püskürtme

INTRODUCTION

Legume grains are very important in human nutrition due to the high protein (twice the cereal). Chickpea is one of the most important grains, which are on second place compared to ordinary beans with 10 million ha sowing area in the world (FAO 2007). Mineral fertilization is one of the most important factors for improving yield, and the crop yield and its quality can be improved by adequate soil and crop management practices. Introduction of high yielding varieties and use of high input fertilizers have caused depletion of micronutrients, mainly of zinc (Zn) on the soil. Approximately 60 percentage of the world soil is considered inadequate for crop production, due to mineral stress caused by the deficiency, unavailability, or toxicity of some essential nutritive elements. Zinc deficiency is one of the most common ones prevalent in the world (Brown *et al.* 1993, Alloway 2004).

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Also, zinc have an important role in the production of biomass furthermore, zinc may be required for chlorophyll production, pollen function, fertilization and germination (Kaya and Higgs 2002, Pandey *et al.* 2006).

The amount of fertilizers that a crop needs depends on many factors including climate conditions, plant species and cultivar, and soil fertility levels (Casa *et al.* 1999). However for micronutrients this can change a little bit, mainly due to their application method as in many cases they are used as foliar sprays (Shirani *et al.* 2010). Also, micronutrients are chemical elements essential for plant growth, required in small quantities. Although the involvement of these micronutrients is small, the lack of any of them can result in significant reductions in production. The application and appropriate doses of zinc in the seeds provide a substantial increase in the level of this nutrient (Salehi Arjmand *et al.* 2014). It was shown that foliar spray of zinc sulfate in canola increased seed yield, capsule number in plant, seed number in pod, thousand weight, seed oil and protein (Bybordi and Malakouti 2007, Omidbeigi 2005). Similarly it was shown that foliar application of zinc has significant increased seed yield, thousand weight and oil content, seed number in pod, oil and seed yield in canola (Siavoushi *et al.* 2004). So according to incredible role of nutrient elements in quantity and quality of crops. Several studies have been shown that a small amount of nutrients, particularly Zn applied by foliar spraying significantly increase the yield of crops (Gadallah 2000, Hebbern *et al.* 2005). Cakmak (2008 and 2010) reported zinc is one of the trace elements which are of essential for the normal healthy growth and reproduction important for beans height quality and yield increase of crop plants.

MATERIALS AND METHODS

This experiment carried out in Kermanshah climate condition, Kermanshah branch in West Iran. According to Domarton's classification the region's climate is semi arid cold with warm summers and cold winters. The climate is characterized by mean annual temperature of 12°C, mean annul maximum temperature of 18°C, mean annual minimum temperature of 2.4°C. Region's soil is clay loam and its pH is in the range of weak to moderate alkalinities (7.6). The Bevanij cultivar was selected for this experiment. The experiment was conducted factorial design based on randomized complete block design (RCBD) in three replications and for 3 years (2010-2013). The zinc sulphate involved 8 levels (control; ZS_0, soil application; ZS_s, foliar spray in early flowering; ZS_f, and foliar spray in early podding; ZS_p and their components as ZS_s ZS_f, ZS_s ZS_p, ZS_f ZS_p, ZS_s ZS_f ZS_p), with two planting seasons; F (fall, sowing date was 7 October), and S (spring, sowing date was 12 March for every year). Each plot consisted of 4 rows with the length of 3 meters, spaced 50cm apart, oriented in an east west direction. The space between the seeds on the rows was 10 cm. After being disinfected with Mancozeb (2:1000) the seeds were planted by hand in the depth of 10 cm. Irrigation were carried out every week during the plant’s growing period. To determine available soil nutrient, samples were analyzed and results are presented in Table 1. It shows that the experimental soil is relatively deficient. Based on the results of soil analysis the potassium and phosphorus fertilizers were not applied but urea was used in the amount of 75 Kg ha^{-1} as the starter fertilizer prior to planting. The time of harvest was determined according to the ripening of 70-80% pods. Length of stem, number of pods per plant, number of seeds in pods, number of unripe seeds, weight of 100 kernel, leaf area, shilling%, yield and harvest index were measured.

Foliar application of micronutrients was conducted at definite times. Concentration of zinc sulfate was considered 8:1000. To increase the absorption of sprayed solution, the surfactant (0.2: 1000) was used in manure solutions, and soil application of zinc sulfate was 25 kg ha^{-1}. In this way, the surfactant decreases the water’s adhesion forces and causes the leaf area to be wet evenly (equally). The plant sprayed early in the morning so that the undesirable effects of sun decrease to the minimum level. Plots that were used as control were sprayed with distillated water to wash over lapping zinc sulfate application. SAS and Excel were used to analyze data and draw graphs, respectively.

Table 1. Physicochemical characteristic of soil.

Texture	Zinc mg.kg^{-1}	Absorbable Potassium	Absorbable Phosphorous	Organic C (%)	Total N (%)	Lime percent	Saturated soil acidity	Electrical Conductivity	Depth
Clay loam	1.01	340	19	1.1	0.13	25.1	7. 6	0.23	0-30

RESULTS AND DISCUSSION

The difference in growth was observed throughout growth period in Zinc sulfate plants. Table 2 contains the results of ANOVA for chickpea grain yield. It is observed that year factor has significant effect on grain yield (at 5% level), but for sowing season and Zinc Sulfate (ZS) is significant in 1% level. Interaction effects for Sowing season ×Year, Year× ZS, Sowing season × ZS and Year×Sowing season × ZS were significant at 1% probability level (Table 2). The results of Table 3 show that, the grain yield average for chickpea in fall and spring sowing season was 1353 and 689 kg ha^{-1}, respectively. Also these results were the same for protein percentage (26 and 24.7% respectively) (Table 5). One of the reasons for these results can be an increase in rain in fall season especially for rainfed farming in Iran climate conditions. The rain averages in fall and spring seasons were 156 and 57mm respectively in recent 10 years duration.

Table 2. Results of ANOVA testing for chickpea grain yield.

Source of Variance	**DF**	**SS**	**MS**	**Comparison**
Year	2	5.654	2.827	495.96*
Replication×Year	6	0.0292	0.0049	<1 ^{ns}
Sowing season	1	15.758	15.758	2794.56**
Sowing season ×Year	2	2.263	1.322	231.9**
Zinc Sulfate (ZS)	7	1.535	0.219	3.84**
Year× ZS	14	1.578	0.113	19.8**
Sowing season × ZS	7	0.758	0.108	18.9**
Year×Sowing season × ZS	14	1.394	0.099	17.36**
Error	90	0.512	0.0057	
Total	143	29.861		

ns: not significant; (*) and (**) represent significant difference over control at p<0.05 and p<0.01, respectively.
DF: Degree of Freedom; SS: Sum of Squares; MS: Means of Squares

Zn deficiency has significant effects on checked plants vegetative growth, and reduced reproductive development of plants (Pandey *et al.* 2006). Also Zn deficiency effects on pollen production, pollen morphology, stigmatic changes, and seed yield of legume crops. Harris *et al*. (2007) reported that zinc sulfate increased the grain yield of maize and wheat 27 and 16 percentage respectively, that is consistent with the results of this study. They stated this yield increase is due to the rapid emergence and early flowering. Bastia *et al*. (1999) improved the number of plant per unit area, number of heads per plant, number of grains per plants, one thousand grains weight and yield of safflower by using zinc application treatments and changing sowing season. Foliar application of zinc sulfate due to an increase in Zn element concentration in both seed and vegetative part of the plants (Alloway 2004).

Table 3. Effects of fertilizer, sowing season and their interaction on chickpea grain yield (kg ha-1)

Average	$ZS_sZS_fZS_p$	$ZS_f\,ZS_p$	$ZS_s\,ZS_p$	$ZS_s\,ZS_f$	ZS_p	ZS_f	ZS_s	ZS_0	**Treatment**
1353 a	1390 ab	1221 c	1389 ab	1524 a	1222 bc	1458 ab	1522 a	1098 cd	fall
689 b	648 ef	754 ef	660 ef	731 ef	686 ef	886 de	606 f	545 f	spring
	1019 cd	987 de	1024 cd	1127 b	954 e	1172 a	1064 c	821 f	Average

LSD 1% = 93.98 kg ha^{-1}

LSD 5% = 70.8 kg ha^{-1}

ZS_p,ZS_f,ZS_s,ZS_0 are non-application of Zinc, soil application of Zinc, early flowering foliar spraying and early podding foliar spraying.

The effect of fertilizer treatments were significant affected by zinc sulfate at 1% level (Table 4). Based on the results of this experiment the soil application and foliar spray application treatments in early flowering were 1172 and 1127 kg ha^{-1} respectively. Also these results were the same for protein percentage (26.9 and 26.4% respectively) (Table 5).

The maximum yield was obtained in treatment of F ZS_S ZS_f (soil application and one foliar spray of zinc sulfate in early flowering in fall sowing season) and treatment F ZS_s (soil application of zinc sulfate in fall sowing season) with yield of 1524 and 1522 kg.ha^{-1}, respectively. Results indicated that application of zinc sulfate increased Zn uptake, grain yield and protein content by soil application at fall planting time (Table 5). It was also showed that in fall sowing season, an application of zinc sulfate in preplanting (25 kg ha^{-1}) and foliar spray in early flowering and in spring season, foliar spray in early flowering could be recommended.

Table 4. Results of ANOVA testing for chickpea grain protein percentage.

Source of Variance	**DF**	**SS**	**MS**	**Comparison**
Replication	2	0.826	0.413	2.68^{ns}
Sowing season	1	7.760	7.760	48.97**
Zinc Sulfate (ZS)	7	31.136	4.448	28.07**
Sowing season× ZS	7	2.971	0.424	2.68**
Error	30	4.754	0.158	
Total	47	47.448		

ns: not significant; (*) and (**) represent significant difference over control at p<0.05 and p<0.01, respectively.

DF: Degree of Freedom; SS: Sum of Squares; MS: Means of Squares.

The relation between protein percentage and zinc concentration was significant, on the other hand, with increase in protein percentage increase zinc concentration (Table 5). But also, grain yield affected by application method of zinc sulfate. The maximum and minimum grain yield obtained in FZS_SZS_F treatment (1524 kg ha^{-1}) and SZS_0 (spring control; 545 kg ha^{-1}). It means that application time and method have significant effect on grain yield (Table 5). Bahmanyar (2004) and Malakouti and Homaei (2004), too, mentioned the application of $ZnSO_4$ fertilizer as the reason for the increase in grain yield, protein percentage and zinc concentration. But, Mahmudi *et al.* (2015) indicated that the highest grain yield was observed under the application of 100 kg K ha^{-1} + 0 kg Zn ha^{-1}. In this experiment zinc concentration evaluated just for each treatment and therefore didn’t analyze.

Table 5. Relationship between zinc concentration, yield and grain protein in different treatments.

Treatment	Grain yield (kg ha^{-1})	Protein percentage (%)	Zinc concentration (%)
F ZS_0	1098 e	25.5 b	32.2 c
F ZS_s	1522 a	24.1 d	33.5 bc
F ZS_f	1458 b	26.9 a	35.6 ab
F ZS_p	1222 d	25.8 ab	33.7 bc
F ZS_s ZS_f	1524 a	26.7 a	37.8 a
F ZS_s ZS_p	1389 c	24.1 d	35.5 ab
F ZS_f ZS_p	1221 d	25.7 ab	36.7 ab
F ZS_s ZS_f ZS_p	1390 c	25.2 b	35.2 ab
S ZS_0	545 f	24.7 c	30.6 d
S ZS_s	606 i	24.1 d	32.5 c
S ZS_f	886 f	25.9 ab	34.2 b
S ZS_p	686 gh	24.7 c	33.8 bc
S ZS_s ZS_f	731 g	24.7 c	34.2 b
S ZS_s ZS_p	660 h	25.2 b	33.9 bc
S ZS_f ZS_p	754 g	24.3 cd	32.8 c
S ZS_s ZS_f ZS_p	648 h	24.8 c	33.1 c

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