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A STUDY OF THE EFFECTS OF $Cl^-/SO_4^=$ RATIOS IN WATER IRRIGATION AND NITROGEN FERTILIZER ON QUANTITY, NUTRIENT UPTAKE, HARVEST INDEX AND NITROGEN EFFECIENCY IN BARLEY (*Hordeum vulgar* L.)

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Abstract. *Environmental conditions such as soil salinity, high temperature, and soil toxicity of heavy metals have harmful effects on plant's growth and nitrogen uptake by root and its metabolism. Changing in osmotic pressure usually relates to varying Cl concentration and excessive sulphate concentration also leads to plant toxicity more than* Cl^- *.Increasing in N concentration in saline soil solution has a positive effect on the other nutrient uptake.*
Many of experts believe that the important progress in cereals production in recent half century has been obtained by harvest index (HI) increasing not necessarily from total biomass growing. A green house experiment was carried out in Ferdowsi University of Mashhad. This experiment was included six $Cl^-/SO_4^=$ *ratios consist of (*C_0S_0, C_1S_1, C_1S_2, C_1S_3, C_2S_1 *and* C_3S_1*) as main treatments and two nitrogen fertilizers (*N_1*=75 Kg/ha and* N_2*= 150 Kg/ha) as sub treatments by using complete randomize design (factorial) with three replications to study* Cl^- *and* $SO_4^=$ *salinity and nitrogen on amount, uptake and nutrient interaction in barley, grain harvest index, N,P,K,Cl,*SO_4 *harvest indices determining, N agronomic efficiency (PFNUE) , N recovery efficiency (PFNRE) and finally N physiological efficiency (PFNUTE) measuring under the predominant of* Cl^- *&* $SO_4^=$ *condition. The results showed that maximum grain and straw yield existed in* C_1S_3 *and* C_1S_2 *ratios and also maximum N, P and K concentration presented in straw and grain in* C_1S_2, C_1S_3 *and* C_1S_1 *ratios. The maximum of N, P and K concentrations under the effects of* $Cl^-/SO_4^=$ *ratios and nitrogen condition showed in low* Cl^- *concentration and high concentration of* $SO4^=$ *too. Maximum of grain and N harvest index showed in* C_1S_3 *treatment, but* C_1S_1 *treatment for P. Maximum of grain and N harvest index under the effects of anion ratios and nitrogen showed in* $C_1S_3N_2$ *and* $C_1S_3N_1$ *treatments, whereas* $C_1S_1N_2$ *and* $C_1S_1N_1$ *treatment for P harvest index. The results also indicated that S harvest index was higher in high* Cl^- *ratios (*C_2S_1 *&* C_3S_1*) because of high sulphate concentration in biomass rather than it in grain in sulphate salinity.*
The results of experiment also showed that PFNUE & PFNRE were maximum in high $SO4^=$ *and low* Cl^- *concentration (*C_1S_3 *and* C_1S_2*) treatments, however, PFNUTE process was opposed to PFNUE & PFNRE. So that, maximum of PFNUTE showed in high* Cl^- *and low* $SO_4^=$ *concentrations (*C_3S_1 *and* C_2S_1*) that it was the reason of antagonistic effect between* $SO_4^=$ *and* NO_3^- *. Observed process in PFNUTE, PFNUE & PFNRE was similar in two levels (75 and 150 Kg/ha) of N and it was double for 75 Kg N /ha rather than 150 Kg N/ha. The use of N fertilizer in saline soils may prevent the stresses of salinity particularly* Cl^- *toxicity through the improvement in growth and yield of barley when* $SO_4^=$ *is a dominant anion.*
***Key Words**: $Cl^-/SO_4^=$ ratios, Nitrogen, Harvest Index, agronomic efficiency, recovery efficiency, and physiological efficiency, Barley*

Introduction

Soil and water salinity problems, deficiencies of sustainable irrigation water included quality and quantity, are the most important problems in agricultural parts of arid and semiarid areas that approximately most parts of Iran encounter them (23).Nearly all plants in saline conditions, will reduce growth which could be related to the concentration of toxic ions as Na and Cl^- in the plant textures .Concentrations of these ions cause the enzyme activity decrease, changing skeletal carbohydrate and metabolite production such as porolin, in plants(12). The relation between ionic absorption and growth is very complex because the maximum concentration of most ions in root zone restricts some of nutrient absorption. Ionic toxicity in plants relates to the type of predominant salt, growth condition and plant species. Pittman (35) showed that chlorate salts and sulphate salts respectively create the maximum and minimum toxic effects and carbonate salts produces the medium effect.

Environmental conditions such as soil salinity, high temperature, and soil toxicity of heavy metals have harmful effects on plant's growth, nitrogen uptake by root, and its metabolism (25). Changing in osmotic pressure usually relates to varying Cl concentration. Moreover, excessive sulphate concentration leads to plant toxicity more than Cl^- (41). Besides osmotic pressure that is made in soil due to chlorate salts, it can be mentioned the harmful effects of Cl^- ion on the organic anion syntheses, reduction in NO_3^- and total nitrogen absorption in the plant and ultimately, disorder in nitrogen metabolism that has deleterious impressions on protein and nucleic acid synthesis (29, 30).Bernstein and Ogata (3) explained that crop reduction by salinity effects is caused by nitrogen deficiency due to high Cl^- amounts .Whereas it has been specified that the increase in nitrogen concentration in saline soil solution, has a positive effect on the other nutrient absorption (24). Heydari et al. (16) in their study on assessment of different levels of salinity and nitrogen on osmotic regulators and nutrient absorption in wheat showed that except magnesium concentration in grain, salinity increases N, Ca, and Mg nutrients absorption and also their concentration in stalk and grain wheat, but decrease K concentration in both parts of the plant for two years of the experiment. Studies have presented that use of urea fertilizer rises the number of flowerets per plant and buds per spick. It also increases 1000 grain weight and wheat harvest index (11).
Harvest index (HI) is the ratio of grain yield to dry matter weight or biomass. Many experts believe that the important progress in cereal production in recent half century were obtained by harvest index (HI) increase not necessarily from total biomass growing (19). Several researchers have reported many negative salinity effects which impress on crop reduction. In addition, they have explained that if there are much soluble salts in soil or nutrient solution, total nitrogen absorption will reduce in wheat. Hence, nutrient efficiency declines in crop increase in saline soils (8, 16 and 20). The world average of nitrogen use efficiency (NUE) in cereal is 18 kilogram of grain for each kilogram of nitrogen use and also nitrogen apparent recovery fraction (NARF) is 33% (36).In Iran, NUE and NARF have low amount because of using N fertilizer in different types, amounts and the time to use fertilizer. The aim of this study are to assess the contemporary effects of Cl^- and $SO_4^=$ salinity and nitrogen on the amount, uptake and interaction of nutrients in barley, to determine the quantity of N, P, K, Cl, SO4, the grain harvest index, N agronomic efficiency (PFNUE), N recovery efficiency (PFNRE) and finally N physiological efficiency (PFNUTE) when of Cl^- & $SO_4^=$ are predominant.

Materials and Method

This experiment consisted of six $Cl^-/SO_4^=$ ratios were as follows C_0S_0, C_1S_1, C_1S_2, C_1S_3, C_2S_1 and C_3S_1 as the main treatments with using $CaSO_4^=$ and $CaCl_2$ salts and two nitrogen fertilizers (N_1=75 Kg/ha and N_2= 150 Kg/ha) as sub treatments by using complete randomize design (factorial) with three replications. This experiment was carried out in Ferdowsi University of Mashhad under green house condition. Furthermore, the control treatment without nitrogen fertilizer with 3 replications was used in order to compare N fertilizer levels. Plastic boxes were selected as cultivation bed with 32×36×36 cm dimensions and then filled with 20 kg soil. Nitrogen requirement as di ammonium phosphate based on barley necessity of phosphate (60 Kg/ha) was calculated for each box and added to the soil before cultivation. The rest of nitrogen fertilizer requirement to 75 and 150 Kg N/ha was added to the boxes with using Urea fertilizer two times during the growth period. Thirty numbers of sterilized barley seed (Karrun dar Kavir variety) were cultivated as ridges and furrows and irrigated with 6 dS/m saline water and different Cl/SO_4 ratios throughout the growth period. The necessary amounts of salt to make saline water was calculated based on $CaSO4^=$ and $CaCl_2$ equivalent calculation for each base period, and after 10 days of cultivation was exerted. Seedlings in each box were become sparse to 16 plants one month after cultivation. In growth period, plants were sprayed with pesticide against green aphid and minose. After plant maturity, some yields and yield component parameters were determined. It was at the end of growth period (120 days after planting) therefore the plants were harvested from the soil surface and transferred to the laboratory to measure essential nutrients. Data were analyzed by MSTAT-C software and means were compared with Multiple Duncan Test Range at 5% level. Plant samples were dried in oven at 70 ºc temperature for 48 hours after transmission to the lab. After that, they were ground and passed from 0.5 mesh sieve for chemical analysis. The measurement of grain and straw nitrogen concentrations was performed by $H_2SO_4^=$ and H_2O_2 in digestion plant samples, as Wolf method (37). Wet digestion method with HNO_3 and $HClO_4$ was used for P and K concentration measurement in the plants due to the fact that wet digestion has more preference than dry digestion for plants with high amounts of silicon such as wheat and barley (37). The N concentration of grain and straw was measured by $H_2SO_4^=$ digestion extract and H_2O_2, as Kjeldahl method (38), and also, the P concentration of samples was specified by spectrophotometer (un/vis wpA – S2000 model), as ammonium molybdate method (38). Flame Photometer was used in order to measure grain and straw potassium in their extract. The amount of Cl^- was measured by 0.02% Normal Ag (NO_3) titration method (38) and $SO_4^=$ concentration in plant samples specified based on Soil and Water Research Institute Regulation (Total Sulfur of plant measurement).
Finally, grain harvest index (GHI) (9), nitrogen, phosphorous, potassium, chlorine and sulfate harvest indexes (39), N agronomic efficiency (PFNUE), N recovery efficiency (PFNRE) and N physiological efficiency (PFNUTE) were calculated by the following formulas (39):

1) Grain Harvest Index = (Grain yield / Total dry matter weight) ×100
2) GNY=GNC×YLD
3) STNY=STNC×STR
4) BNY= GNY+STNY

5) Nitrogen Harvest Index (NHI) = $\frac{GNY}{BNY}$

6) Partial Factor N Use Efficiency (PFNUE) ($gg^{-1}m^{-2}$) = $\frac{YLD_f}{N_f}$

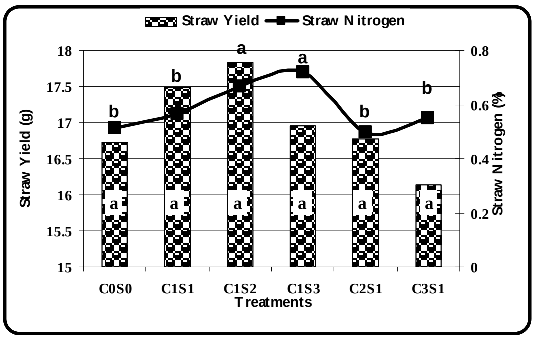
7) Partial Factor N Uptake Efficiency (PFNRE) (%) = $BNY_f \times \frac{100}{N_f}$

8) Partial Factor N Utilization Efficiency (PFNUTE) ($gg^{-1}m^{-2}$) = $\frac{YLD}{BNY}$

Where GNY is the grain nitrogen yield, GNC is the grain N concentration, YLD the grain yield, STNY the straw N yield, STNC the straw N concentration, STR the straw yield, NHI the nitrogen harvest index, BNY the biomass N yield, f the abbreviation of fertilizer, and N_f is N fertilizer level respectively.

Results and discussion

Maximum straw (Fig.1) and grain (Fig.2) N concentration showed in C_1S_2 and C_1S_3 treatments without any significant differences. Increase in Cl/SO_4 anion ratios reduced the straw and grain yield and N concentration in both parts of the plant. Salinity decreases nitrogen concentration in the plant, as several reasons such as low absorption due to root leaching reduction, decrease in microbial activities that causes declining in the organic compound mineralization, nitrification process and competition among Na^+, Cl^- ions with ammonium and nitrate during uptake. A study on interaction between two pistachio varieties against the amount and type of saline soils was showed increase in SO_4 ratio decreased the salinity harmful effects in different salinity levels (1). Hence, in Na_2SO_4 salinity, stalk dry matter yield increased more than 1.5 times and leaf dry matter yield grew more than 1.7 times than NaCl salinity in the treatment.



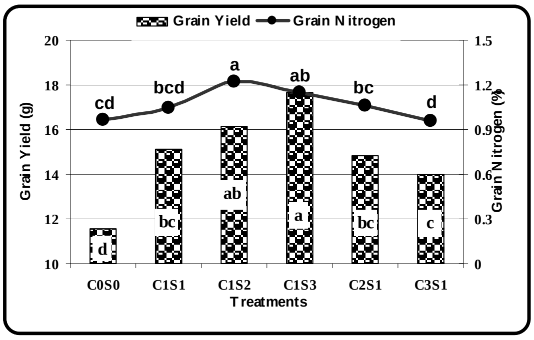
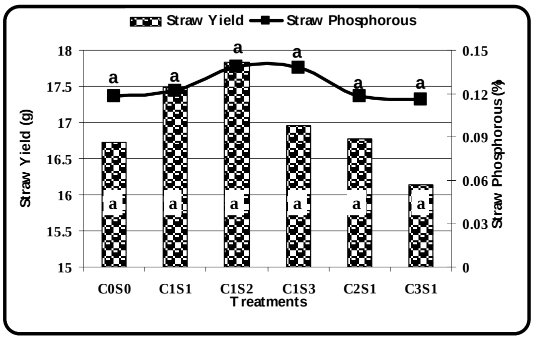


Fig 1. Effect of Cl/SO_4 ratios on N straw Concentration. Fig 2. Effect of Cl/SO_4 ratios on N grain concentration.

Maximum P concentration of straw and grain (Fig. 3 and 4) showed in C_1S_2 and C_1S_1 treatments and minimum of them showed in C_2S_1 treatment in both parts of the plant. P concentration in grain didn't show a significant difference among the other treatments. In saline condition, phosphorous activity in soil solution reduces due to ionic strength increasing (26), whereas in high electrolyte concentration and salinity more than low salinity; phosphorous absorption increases in soil so that a little phosphorous is available for root in soil solution (13). Salinity has intense effects on the root which reduces the root's growth and as a result it affects on surface absorption so that P uptake (P is fairly immobile nutrient in soil) decreases in the soil (14).In addition, It may be possible that SO_4 and Cl anions prevent P uptake by the root, and consequently decreasing phosphorous concentration in the grain (13).



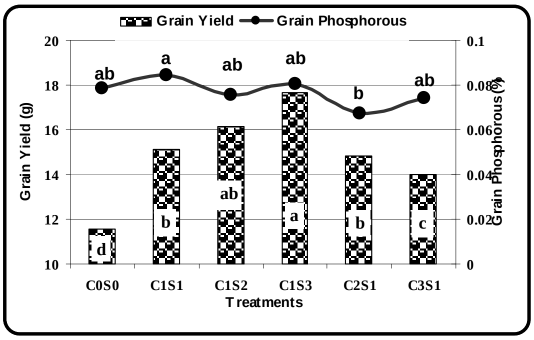
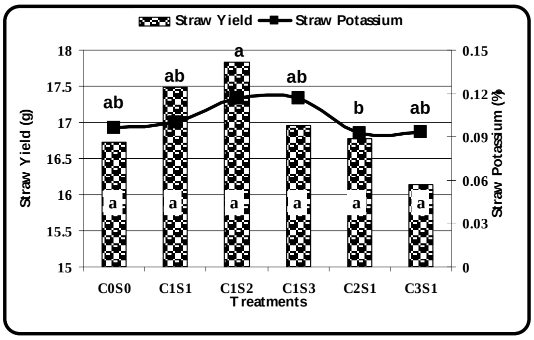


Fig 3. Effect of Cl/SO_4 ratios on P straw Concentration. Fig 4. Effect of Cl/SO_4 ratios on P grain concentration.

Malakouti et al. in their study on wheat, barley, maze and millet by quotation from Maliwal and Paliwal (27) showed that the ability to use P increased to maximum salinity 5.6 to 6 dS/m, and exchangeable sodium percentage (ESP) to 30% and then it decreased in higher amounts of them. Champagnol (6) announced that adding P in soils which have P deficiency is useful when the crop doesn't encounter intense salinity condition. Besides ionic solution strength, P uptake can be prevented by competition with Cl^-, for example in barley and sunflower the higher concentration of Cl^- than SO_4 affected on P uptake (6).

The maximum and minimum potassium straw concentration under effect of Cl/SO_4 ratios observed in C_1S_2 and C_2S_1 respectively (Fig. 5). Daroudi and Siadat (8) showed that due to existing a strong correlation between Cl^- and K concentration in filament's leaf of wheat and a poor correlation between Cl^- and other cations in saline condition, probably some of the uptake potassium by the plant has limited to naturalize Cl^- electrolyte charge in vacuoles and it does not help to vital interactions, so that symptoms of K deficiency appears in wheat in spite of high potassium concentration in wheat's shoots. Potassium concentration in the grain (Fig. 6) under effect of experimental treatments has not had a special process and only in C_2S_1 treatment showed more significant reduction than C_1S_1 treatment. Some experts reported potassium reduction in barley because of salinity (15).



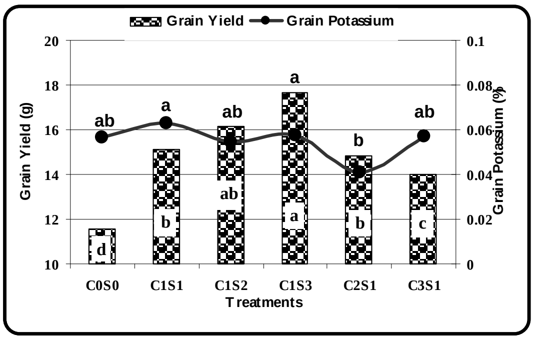
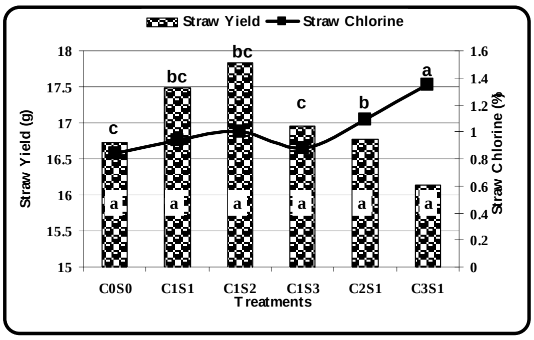


Fig 5. Effect of Cl/SO_4 ratios on K straw Concentration. Fig 6. Effect of Cl/SO_4 ratios on K grain concentration.

The results of potassium usage effects on relative tolerance in tree varieties of pistachio to salinity stress showed that although potassium usage did not have the significant effect on some growth's properties, it affected on biochemical indexes significantly so that it slightly balanced harm effects of salinity stress (40).Potassium with increasing prolin concentration and consequently osmotic conformity increases the plant tolerance to salinity stress (40).



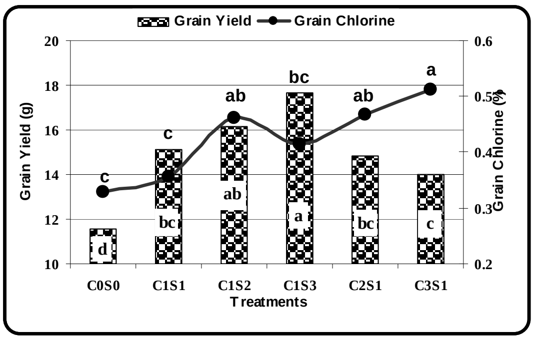
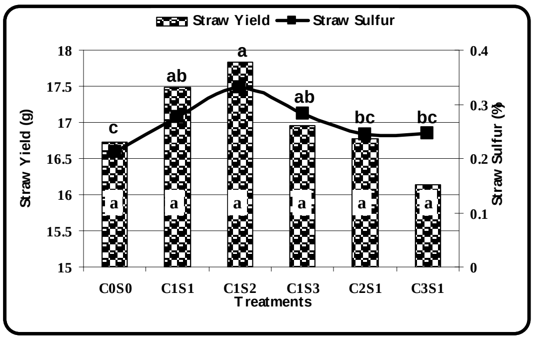


Fig 7. Effect of Cl/SO_4 ratios on CL straw Concentration. Fig 8. Effect of Cl/SO_4 ratios on CL grain concentration.

The maximum of Cl concentration was observed in the C_3S_1 treatment for straw which it had a significant difference to the other experimental treatments (Fig.7). The minimum of Cl concentration was shown in C_0S_0 and C_1S_3 treatments which did not have a significant difference to C_1S_1 and C_1S_2 in 5% level. The maximum concentration of Cl in the grain was seen in C_3S_1 and C_2S_1 without any significant differences to each other. C_0S_0 and C_1S_1 treatments with the minimum concentration didn't have a significant difference with each other in 5% level. Two treatments (C_1S_3 and C_1S_2) also didn't have a significant difference with each other which were observed after C_3S_1 and C_2S_1 treatments, as the next order (Fig.8).The studies on the soil salinity and type of salt on primary establishment and plant's growth such as *Atriplex canescens* , *Halimion verrucifera* , … showed that the yields of all species in sulfate salt was more than yields in chloride salt treatments (31). The maximum sulfur concentration (Fig.9) in plant's straw was observed in C1S2 and C1S3 treatments that it was predictable according to sulfate salt usage. The changing process of grain sulfur concentration in barley was similar to straw sulfur concentration (Fig.10).



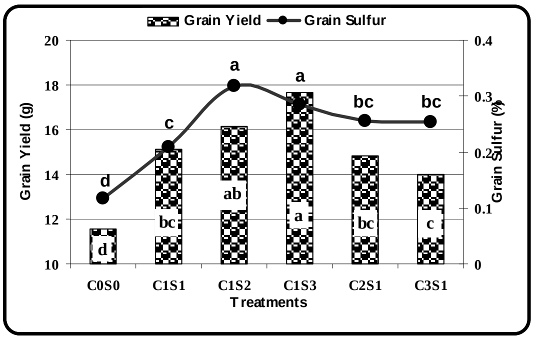


Fig 9. Effect of Cl/SO_4 ratios on S straw Concentration. Fig 10. Effect of Cl/SO_4 ratios on S grain concentration.

The study on N, P, K, Cl, S nutrient concentrations in both parts of the plant (straw and grain) under effect of N fertilizer usage levels did not show a significant difference in 5% level (Table 1).
The study on the salinity levels with Cl/SO_4 ratios (1:2, 1:1 and 2:1) and two nitrogen levels (100 and 200 Kg/ha) on wheat showed that increase in the amount of N fertilizer in soils with Cl/SO_4 ratios (2:1 and 1:1) can create positive effects on dry matter weight of shoots (10). Researches on maze (27) showed that the maximum anion absorption comparing to cation absorption in sulfate salinity was larger than chloride salinity in the soil.

Table 1 Effect of nitrogen levels (70 and 150 Kg/ha) on some nutrients in straw and grain of barley

Treatments	Straw N (%)	GrainN (%)	Straw P (%)	Grain P (%)	Straw K (%)	Grain K (%)	Straw Cl (%)	Grain Cl (%)	Straw S (%)	Grain S (%)
N_1	0.556a	1.066a	0.124a	0.077a	0.101a	0.079a	1.089a	0.428a	0.259a	0.214a
N_2	0.615a	1.067a	0.124a	0.076a	0.104a	0.055a	0.943a	0.419a	0.272a	0.265a
±Sd	0.0957	0.125	0.02030	0.0109	0.0183	0.0605	0.2811	0.0815	0.0556	0.0764

Means within a column followed by the same letter are not significantly different at p = o.o5

The maximum straw N concentration under effects of anion ratios and nitrogen was observed in $C_1S_3N_2$ and then $C_1S_3N_1$ and $C_1S_2N_2$ respectively (Table 2) showing low Cl concentration and high concentration of SO_4 caused increasing N concentration of straw. The maximum concentration of N in grain was seen in $C_1S_2N_1$, $C_1S_3N_1$ and $C_1S_2N_2$ like the process of straw nitrogen concentration (Table 2). Brohi et al. (5) explained that the amounts of N, P, K in the grain and straw was proportional to N and P fertilizer use in the plant. In some plants such as pepper, soybean and mustard NO_3^- limits Cl absorption which improves the growth in salinity stress condition (32).
The maximum P concentration in the plant's straw, under effects of anion ratios and nitrogen (Table 2), was shown in $C_1S_2N_1$, $C_1S_3N_1$, $C_1S_2N_2$, $C_1S_3N_2$, and $C_1S_1N_2$ treatments which had no significant difference with each other at 5% level. Belay et al. and Bernstein (2 and 4) realized that N, P, K fertilizer adding is the reason of available P increasing for the plant. P concentration of grain in $C_0S_0N_2$ was maximum which showed more significant difference than $C_0S_0N_1$, $C_2S_1N_1$ and C_3S_1N treatments (Table 2).

Table 2 effect of Cl/SO_4 ratios and nitrogen levels (70 and 150 Kg/ha) on some nutrients in straw and grain of barley

Treatments	Straw N (%)	Grain N (%)	Straw P (%)	Grain P (%)	Straw K (%)	Grain K (%)	Straw Cl (%)	Grain Cl (%)	Straw S (%)	Grain S (%)
$C_0S_0N_1$	0.512de	0.917ef	0.113c	0.069bcd	0.086cd	0.046b	0.732f	0.371cde	0.196c	0.094e
$C_0S_0N_2$	0.519de	1.007def	0.123abc	0.088a	0.106abcd	0.067ab	0.946cde	0.286c	0.226cde	0.139de

$C_1S_1N_1$	0.507e	1.009de	0.114c	0.084ab	0.094cd	0.064ab	1.024bcd	0.358de	0.277bc	0.148d
$C_1S_1N_2$	0.625bc	1.088cd	0.129abc	0.084ab	0.105bcd	0.061ab	0.854def	0.354de	0.276bc	0.270bc
$C_1S_2N_1$	0.642bc	1.328a	0.152a	0.080abc	0.130a	0.060ab	.0877def	0.445abcd	0.353a	0.303ab
$C_1S_2N_2$	0.688ab	1.117bc	0.125abc	0.071bcd	0103bcd	0.049b	1.121bc	0.476ab	0.309ab	0.334a
$C_1S_3N_1$	0.691b	1.196b	0.146ab	0.084ab	0.122ab	0.060ab	0.931de	0.398bcd	0.215de	0.232c
$C_1S_3N_2$	0.745a	1.096bcd	0.128abc	0.076abcd	0.110abc	0.054ab	0.833ef	0.431abcd	0.350a	0.336a
$C_2S_1N_1$	0.463e	1.041cd	0.103c	0.064d	0.082d	0.173a	1.173b	0.475ab	0.277bc	0.243c
$C_2S_1N_2$	0.531de	1.088cd	0.120bc	0.070bcd	0.101bcd	0.050b	1.001bcde	0.460abc	0.210de	0.266bc
$C_3S_1N_1$	0.520de	0.901f	0.115c	0.083ab	0.093cd	0.067ab	1.797a	0.522a	0.234cde	0.261bc
$C_3S_1N_2$	0.583cd	1.009de	0.116bc	0.064cd	0.094cd	0.047b	0.900def	0.504a	0.259bcd	0.244c
±Sd	0.0957	0.125	0.02030	0.0109	0.0183	0.0605	0.2811	0.0815	0.0556	0.0764

Means within a column followed by the same letter are not significantly different at p = o.o5

In more cases, P usage in saline soil increases plant's growth and crop's yield although plant salinity tolerance reduces with rising in salinity from a low level to a high level and also with usage of phosphorous. In addition, results of some researches have shown that salinity increases phosphorous uptake in a plant or it had no effect on its uptake (6).

Potassium concentration in straw and grain of the plant has not shown an especial process. Maximum of Potassium concentration was observed in $C_1S_2N_1$, $C_1S_3N_1$ treatments for straw and in $C_2S_1N_1$ for grain (Table 2). Sulfate salinity compared with chloride salinity caused P, K, Mg, $SO_4^{=}$ rising in the plant, especially in leaves, whereas Na, Fe, and Cl concentration decreased in leaves. However, Ca concentration was approximately equal in Sulfate and chloride salinity (33). The chloride changing process in straw and grain was similar under effect of experimental treatments and Cl/SO_4 anion ratios usage, as the maximum of Cl concentration was shown in $C_3S_1N_1$ and $C_3S_1N_2$ for straw and grain (Table 2). Maximum of SO_4 concentration in straw was observed in $C_1S_2N_1$, $C_1S_2N_2$ and $C_1S_3N_2$ without s significant difference (Table 2) and minimum of it was shown in the $C_0S_0N_1$ treatment. SO_4 concentration of grain was max in $C_1S_3N_2$ and $C_1S_2N_2$, while it was minimum in $C_0S_0N_1$, $C_0S_0N_2$ and $C_1S_1N_1$.Besides in minimum treatments, there was not any reciprocal significant differences at 5% level (Table 2). The results of researches which have been performed explain that sulfur as acidic matter could reduce soil PH around roots and improve growth and crop yield with increase the nutrient uptake (21 and 42).

The study of the grain harvest index (GHI) under effect of Cl/SO_4 anion ratios (Table 3) showed that GHI in all treatments increased to the control (C_0S_0 treatment), and the maximum of rising was shown in C_1S_3 treatment with 25.7% increase. Comparing of other experimental treatments did not show a significant difference with each other in 5% level. Researchers on the study of nitrogen optimum management for crop increasing and improving the quality of the yield in wheat field deduced that with soil salinity rising, the number of spike per plant and crop harvest index declines (20). The study on the nitrogen harvest index showed that the maximum nitrogen harvest amount with 4.9% increase in relation to the control was obtained in C_1S_3 and the minimum was acquired in C_2S_1 and C_3S_1 with 5.5% and 2.6% decrease to the control, respectively (Table 3).With rising the amount of urea fertilizer as foliar on leaves, the number of bud in spike, harvest index, grain yield, leaf area index, leaf stability area, and grain protein percentage increased, compared to the control (11). The foliar of urea fertilizer at the end of the tiller stage had the maximum effect on number of tillers, productive tiller per plant, the number of bud per spike, harvest index, leaf area index, leaf area stability and grain yield compared to other stages (11). The maximum and minimum phosphorous harvest indexes under effect of Cl/SO_4 anion ratios (table 3) were shown in C_1S_1 and C_1S_2 with 2.5% increase and 11.5% decrease compared to the control, respectively. Comparing other treatments with each other and also with the control had no significant differences in 5% level (Table 3). The study of the potassium harvest index and chlorine harvest index under effect of Cl/SO_4 ratios (Table 3) did not show significant differences in none of experimental treatment in 5% level. However, the sulfur harvest index increased in all treatments to the control as the maximum increasing was shown in C_2S_1, C_3S_1 and C_1S_3 treatments without any significant differences with each other (Table 3). Researchers in a study on the effect of water irrigation salinity (EC= 2.2-24 mmoh/cm) on yield and nutrient harvest indexes in barley, has explained that plant yield was economic to EC= 16 mmoh/cm, although in the high salinity levels, grain yield decreased about 43.5% more than the salinity level of 2.2 mmoh/cm. In addition, with increasing in salinity amounts, nitrogen, phosphorous, and harvest index decreased, whereas potassium and sodium increased (34).

The study of the grain harvest index and nutrient (N, P, K, Cl, SO_4) harvest indexes under effects of two nitrogen levels (75 and 150 Kg/ha) did not show significant differences with each other.

Table 3 effect of Cl/SO_4 anion ratios on nutrient harvest indexes and plant

Treatments	Grain Harvest Index (GHI)	Nitrogen Harvest Index (NHI)	Phosphorous Harvest Index (PHI)	Potassium Harvest Index (KHI)	Chlorine Harvest Index (CLHI)	Sulfur Harvest Index (SHI)

C_0S_0	40.55c	65.01ab	39.94ab	36.82a	28.43a	35.59c
C_1S_1	46.31b	65.08ab	40.95a	38.58a	27.58a	42.05bc
C_1S_2	47.52b	64.68ab	35.33b	31.98a	31.70a	49.03ab
C_1S_3	51.0a	68.20a	37.08ab	33.16a	32.06a	50.48a
C_2S_1	46.92b	61.42b	37.74ab	41.34a	30.35a	51.34a
C_3S_1	46.44b	63.32b	38.93ab	37.76a	29.34a	50.61a
±Sd	3.598	3.261	3.650	10.324	5.177	8.175

Means within a column followed by the same letter are not significantly different at p = o.o5

The maximum grain harvest index under effect of anion ratios and nitrogen was shown in $C_1S_3N_2$ and $C_1S_3N_1$, respectively, while the minimum was observed in $C_0S_0N_1$ and $C_0S_0N_2$ treatments that they had a similar process with grain harvest index under effect of anion ratios (Table 4). Comparing other indexes with each other did not show significant differences in 5% level. The maximum of nitrogen harvest index in the plant under effect of anion ratios and nitrogen was shown in $C_1S_3N_2$, $C_1S_3N_1$ and $C_2S_1N_2$ and the minimum of it was shown in $C_1S_2N_1$, $C_1S_2N_2$ treatments, respectively. Moreover, the maximum phosphorus harvest index in the plant was similar to anion ratios in $C_1S_1N_2$, $C_1S_1N_1$ and $C_1S_3N_1$ treatments (Table 4). Comparing of experimental treatments for potassium harvest index did not show significant differences in any treatments in 5% level (Table 4).The chlorine harvest index process in the plant from the soil was similar to Cl increasing ratio in the experimental treatments. The maximum of CLHI, therefore, was shown in $C_3S_1N_2$, $C_3S_1N_1$ and $C_1S_3N_1$ treatments. The assessment of the sulfur harvest index (table 4) showed that rising in Cl/SO_4 anion ratios somewhat affected on sulfur uptake of the plant as the maximum of SHI was shown in $C_2S_1N_2$ and $C_3S_1N_1$ treatments. Soil salinity chloride had a positive correlation with increasing the concentration of mono valance cations in the plant as the amounts of mono valance cations in Cl salinity is higher than amounts of them in SO_4 salinity (33). SO_4 salinity increased SO_4 concentration especially in the plant's leaves (33). Because the harvest index is the ratio of grain to biomass, so SHI is further than in high ratios of Cl/SO_4.

Using of sulfur as a pH reducer and modifier has been more attended (17). In China, sulfur usage increased the yield of rapeseed around 13.4% (17). In addition, sulfur usage increased the efficiency of nitrogen and phosphorous fertilizers as usage of 1 Kg sulfur increased peanut (22), soybean (7) and rapeseed yield 9.3, 8.13 and 4.5 Kg, respectively (15).

Table 4 effect of Cl/SO_4 anion ratios and N levels (75 and 150 Kg/ha) on nutrient harvest indexes and plant

Treatments	Grain Harvest Index (GHI)	Nitrogen Harvest Index (NHI)	Phosphorous Harvest Index (PHI)	Potassium Harvest Index (KHI)	Chlorine Harvest Index (CLHI)	Sulfur Harvest Index (SHI)
$C_0S_0N_1$	37.22e	64.07bcd	38.03ab	34.74a	22.52e	32.70d
$C_0S_0N_2$	43.88d	65.94abc	39.41ab	38.89a	23.27de	38.47cd
$C_1S_1N_1$	45.58cd	66.55abc	41.84a	40.47a	25.88cde	34.75d
$C_1S_1N_2$	47.04bc	63.31bcd	42.50a	36.68a	29.28bcd	49.35ab
$C_1S_2N_1$	47.80b	59.55e	34.46b	31.85a	29.93bc	46.20bc
$C_1S_2N_2$	47.24bc	61.90de	36.20b	32.12a	29.70bc	51.86ab
$C_1S_3N_1$	50.51a	67.45ab	42.18a	33.39a	33.70ab	51.99ab
$C_1S_3N_2$	51.49a	69.23a	37.62ab	32.94a	34.19ab	48.97ab
$C_2S_1N_1$	47.65b	63.30cde	38.19ab	49.25a	28.94bcd	46.71b
$C_2S_1N_2$	46.18bc	67.18abc	37.30ab	33.43a	31.76abc	55.96a
$C_3S_1N_1$	47.35bc	63.28cde	36.55b	42.12a	33.60ab	52.63ab
$C_3S_1N_2$	45.53cd	63.38cde	35.68b	33.40a	36.17a	48.59ab
±Sd	3.598	3.261	3.650	10.324	5.177	8.175

Means within a column followed by the same letter are not significantly different at p = o.o5

The evaluation of N agronomic efficiency (PFNUE) and N recovery efficiency (PFNRE) in 75 Kg/ha of N level under effect of Cl/SO_4 ratios (Fig. 11) showed that the maximum PFNUE (nitrogen transition from fertilizer to grain) and PFNRE (nitrogen transition from fertilizer to biomass) were in C_1S_3 and C_1S_2 treatments which had more significant difference than other experimental treatments .The minimum of PFNUE and PFNRE was shown in C_0S_0 treatment (Fig. 11), whereas the maximum of N physiological efficiency (PFNUTE) (nitrogen transition from biomass to grain) was observed in C_3S_1, C_2S_1, and C_0S_0 treatments. Nitrogen fertilizer usage for crops which were planted in salinity condition is useful when salinity is low or medium. However, when salinity was very high, the crop yield decreased 50%. Consequently, fertilizer use efficiency declined (25). The N, P, and K use efficiencies of impure yield of sugar beet for a 28-year period were studied in five important areas in Greek and it was found that with rising in fertilizer usage the NPK use efficiency decreased (28).

The process shown for N agronomic efficiency (PFNUE), N recovery efficiency (PFNRE), and N physiological efficiency (PFNUTE) for 150 Kg/ha N level under effect of anion ratios was similar to 75 Kg/ha N level (Fig. 12). Although, the amounts of PFNUE and PFNRE in 75 Kg/ha N level were approximately twice of these amounts in 150 Kg/ha N level.

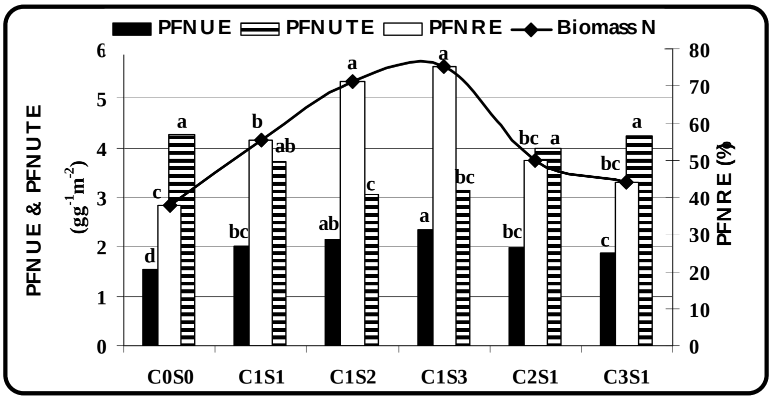


Fig11. Effect of anion ratios on N agronomic efficiency (PFNUE), N recovery efficiency (PFNRE) and finally N physiological efficiency (PFNUTE) in 75 Kg N/ha

Researchers (18) in a study of the effect of saline water (4,8 and 12 dS/m) on nitrogen and potash use efficiency in sugar beet planting, explained that with increasing in salinity, yield and sugar percentage decreased, significantly. Consumption of 25% nitrogen more than the recommended amount in non-saline lands caused a significant increase in roots, shoot yield, non-sugar yield, and obtainable sugar. However, extra nitrogen consumption decreased these parameters (18). Extra nitrogen consumption more than non-saline lands did not affect on quality parameters except the harmful nitrogen root and also nitrogen solely increased as harmful nitrogen significantly. Consequently, NUE decreased with increasing nitrogen consumption on root yield, non-sugar, and obtainable sugar.

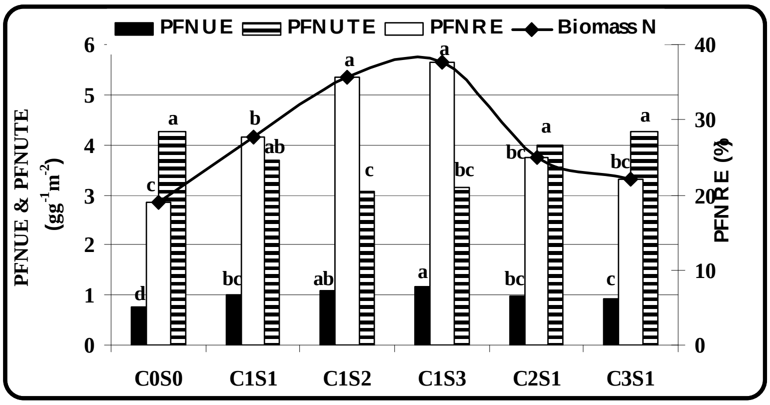


Fig12. Effect of anion ratios on N agronomic efficiency (PFNUE), N recovery efficiency (PFNRE) and N physiological efficiency (PFNUTE) in 150 Kg N/ha

Comparing the results in table 5 the for biomass nitrogen yield under effect of anion ratios and nitrogen levels showed that the maximum amount of N was, respectively in $C_1S_3N_2$, $C_1S_2N_2$, $C_1S_3N_1$, and $C_1S_2N_1$ treatments which had no significant difference with each other in 5% level.

Changing process of N agronomic efficiency was similar in both nitrogen levels (75 and 150 Kg/ha) as the $C_1S_3N_2$ and $C_1S_3N_1$ treatments were maximum, whereas the minimum of PFNUE was shown in $C_3S_1N_2$, $C_3S_1N_1$ and $C_0S_0N_1$, respectively (Table 5). Comparing the N recovery efficiency in both nitrogen levels (75 and 150 Kg/ha) was similar to the N biomass yield as $C_1S_3N_2$, $C_1S_2N_2$, $C_1S_3N_1$ and $C_1S_2N_1$ treatments had the maximum PFNRE under effect of interaction between anion ratios and nitrogen (Table 5).

The maximum N physiological efficiency (PFNUTE) in the plant was shown in the $C_0S_0N_1$, $C_3S_1N_1$, $C_1S_1N_1$, $C_3S_1N_2$ treatments and the minimum in the $C_1S_2N_2$,$C_1S_2N_1$, $C_1S_3N_2$ and $C_1S_3N_1$ (table 5).

Researches have been done on cotton in saline conditions showed that there was not a balance between cation and anion ratios and also between mono valance cation and two valence ratios in the plant. Hence, the amounts of mono valence cations usually increased with increasing in salinity stress and temporary withered of the plant, but at the end of the growth stage and plant maturity, mono valance to two valance cation ratios were further which shows there was not ionic balance in the plant as the result of salinity (33).

Table 5 interaction effects between anion ratios and N levels (75 and 150 Kg/ha) on N agronomic efficiency (PFNUE), N recovery efficiency (PFNRE) and N physiological efficiency (PFNUTE)

Treatments **Unit**	Biomass N Yield (BNY)	N agronomic efficiency ($gg^{-1}m^{-2}$)	N agronomic efficiency ($gg^{-1}m^{-2}$)	N recovery efficiency (%)	N recovery efficiency (%)	N physiological efficiency ($gg^{-1}m^{-2}$)
Nitrogen level	-	75 Kg N/ha	150 Kg N/ha	75 Kg N/ha	150 Kg N/ha	-
$C_0S_0N_1$	2.033e	1.222f	0.611f	27.10e	13.55e	4.667a
$C_0S_0N_2$	3.658d	1.867de	0.9333de	48.77d	24.38d	3.856cde
$C_1S_1N_1$	3.455d	1.885de	0.942de	46.07d	23.03d	4.091abcd
$C_1S_1N_2$	4.866bc	2.147bc	1.073bc	64.88bc	32.44bc	3.319efg
$C_1S_2N_1$	5.091ab	2.076bcd	1.038bcd	67.88ab	33.94ab	3.074g
$C_1S_2N_2$	5.586ab	2.231b	1.116b	74.48ab	37.24ab	3.049g
$C_1S_3N_1$	5.301ab	2.249ab	1.124ab	70.68ab	35.34ab	3.187fg
$C_1S_3N_2$	5.976a	2.458a	1.229a	79.67a	39.84a	3.094g
$C_2S_1N_1$	3.407d	1.946cde	0.9737cde	45.43d	22.71d	4.295abc
$C_2S_1N_2$	4.093cd	2.004cde	1.002cde	54.58cd	27.29cd	3.689def
$C_3S_1N_1$	3.229d	1.925cde	0.962cde	43.06d	21.53d	4.5ab
$C_3S_1N_2$	3.398d	1.809e	0.9063e	45.31d	22.65d	4.005bcd
±Sd	1.235	0.317	0.158	16.47	8.235	0.639

Means within a column followed by the same letter are not significantly different at p = o.o5

Maybe one of the reasons for the N physiological efficiency reduction in the treatments with high SO_4 concentration is existing antagonistic effects between SO_4 and NO_3 ions (10 and 33). At the plant's physiological maturity time, SO_4 anion limited uptake and concentrate of NO_3 anion in the grain. Therefore, NO_3 concentration reduced in the grain, so N physiological efficiency decreased in treatments with high SO_4/Cl ratios.

In salinity condition, the plant fights salinity and consumes energy to increase salinity stress tolerance and water deficiency recovery. In addition, it needs to consume energy to transform the absorbed NO_3 from the soil and retransform it to NH_3 in ammounification process and then produce protein. Consequently, the plant will encounter problems and energy deficiency during the nitrogen uptake and concentration in the grain, especially, when predominant anion is SO_4.

Nutrient uptake by the plant not only under effect of SO_4 and Cl salts was different, but also it could be related to nitrogen forms in this condition. Hence, in salinity chloride with high concentration of Cl and NO_3 nitrogen forms, the amounts of Ca, Mg, and K cations increase comparing with ammonium nitrogen.

The results of researches performed on cotton (33) showed that the anatomic changing in early stages of the plant's growth under effect of Cl salinity reduced the leaf area size and the number of openings in the leaf area, whereas the root's epidermal cell size and thickness of the main rip on the leaf increased. In addition, harmful effects of SO_4 were decrease in cells' growth more than the new cells' generation, while Cl harmful effects is almost limitation on new cells' production, but it approximately simulates the plant's growth (33).

Furthermore, the results of the researches performed on wheat in Cl-SO_4 saline condition showed that the consumption of the nitrogen fertilizer can use for the growth's simulation, wheat's maturity and limitation of salinity stress in saline soils in the condition which SO_4 anion is predominant and anion variety of Cl/SO_4 ratios is 1:1 or 1:2 (10).

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