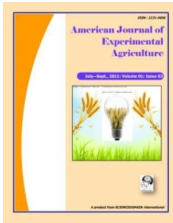

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The Effect of Macro and Micro-nutrient Fertilizers on Yield and Yield Attributes of Rice in a Calcareous Soil

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

In order to examine the effect of macro and micronutrient fertilizers on the growth and yield of rice (*Oryza sativa* L.) under calcareous soils, the experiment carried out as split- split plot design in randomized complete block with three replications. Macro, sulfur powder and micronutrient fertilizers have chosen as main, sub and sub-sub plots, respectively. The amount of lime and pH of the experimental soil is 16.7% and 7.54, respectively that categorized as calcareous soils. The aim of the present study is decrease soil pH at the five stages of rice plant growth and investigation of vegetative growth and rice grain yield. The results showed that soil pH decreased by using NPK+S+Zn fertilizers (0.32) compared to the control plot. With decreasing soil pH all the agronomic characteristics of rice plant and its grain yield increased significantly, except 1000-grain weight. The number of filled grain (119) and total number of seed per panicle (127) and grain yield (4376 kg ha^{-1}) reached at the maximum values when NPK+S+Zn fertilizers applied together. Rice grain yield was increased 1483 kg ha^{-1} by this treatment compared to the control plot (2893 kg ha^{-1}). Thus, this treatment can be resulted as the best treatment under calcareous soils conditions with high soil pH.

Keywords: Macro and micronutrient; Calcareous soil; Growth; Yield; Rice.

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1. INTRODUCTION

The two greatest problems faced by the third world countries, at present, are the exponential increase in population and the basic need for providing adequate food. With the increasing population each year, the demand for foodstuff also increases and it will have to be balanced obviously by a qualitative and quantitative increase in food production. The food production in turn can be improved only by improving the conditions of arable soil and the correct use of fertilizers. More than half of arable soils of the world where the plant can be cultivated and grown are belonged to alkaline or calcareous soils. The presence of excess amount of lime or Na element in these soils disorders the nutrition uptake especially micronutrient elements and finally injures plant growth [1,2]. On the other hand, the anomalous use of nitrogen and phosphorous fertilizers are common for growing high yield varieties of crops but it has been found to decrease the uptake capability of plants for micronutrients. Incredibly, over 3 billion people are afflicted with micronutrient malnutrition and the numbers are increasing [3]. Furthermore, certain micronutrient deficiencies are an issue even in developed countries such as the United States. The uptake of Zn, Cu, Mn and Fe elements by plants is retarded if the soil is alkaline and is limy [4]. Generally, alkaline soils are deficient in micronutrients compared to the acidic soils. About 30% of the agricultural soils of the world face the lack of these elements [5]. In addition to the frequent use of super-phosphate fertilizers, the plantation at short intervals also causes a decrease in the density of micronutrients in arable soils. The plant growth is also affected in soils deficient in micronutrients even the use of N, P and K fertilizers cannot help in increasing the grain yield. The rice plant is special to the tropical countries, and care should be taken in choosing the fertilizer and the method of its use. Amongst the recognized macronutrients, like N, P, K, Ca, S and Mg the rice plant needs more N, P and K. This plant is susceptible to Zn and Cu deficiency, more than other micronutrients. Survey of the literature reveals that the farmers in Asia are not applying all the nutrients needed, even though intensive modern agriculture has depleting effect. They tend to apply too much nitrogen and no micronutrients at all. With each cropping season, micronutrients are removed in the harvested crop and are not being replaced. The result of this mining of nutrients is widespread micronutrient deficiency problems all over Asia. Micronutrient problems are a serious constraint to productivity in the Asian and pacific region, and are tending to become more serious year by year. Unfortunately, the use of chemical fertilizers in Iran is also imbalanced and does not take into account the actual necessary need of the crop plant or the nature of the soil.

Next to wheat most of arable soil of the world is used for rice growing. Suitable growth of this plant is under the acidic soil pH (5.5 to 6.5) condition, where most nutrients can be taken up by the plant especially micronutrients [6]. Fajeria et al. [7] reported that the best rice yield is obtained in the soil that has pH about 6 and it decreases in higher pH. At that pH (6.0), the absorption of P, Fe, Zn and Mn by rice plant also increased [8]. The pH of soil decreases by addition of sulfurous and nitrogen fertilizers [9]. The addition of 100 kg ha^{-1} of $ZnCl_2$ also showed an increase in the rice yield [10]. Other experiments carried out by Malakoti and Tehrani [11] and Fallah and Saadati [12] who reported that with using Zn and Cu fertilizers grain yield increases. The main objective of the present study is to examine the effect of macronutrients such as N, P and K and the effect of sulfur powder on soil pH and micronutrients such as Zn, Cu and Mn and its relationship with soil pH on growth and the yield and yield components of rice.

2. MATERIALS AND METHODS

The present experimental soil has adequate Ca^{2+} available in the form of $CaCO_3$ and has been categorized as calcareous soil containing sufficient lime (16.7%) with soil pH (7.62). The amount of E.C, S.A.R, E.S.P, CEC, OC and OM percentage and P, K, Zn, Cu, Mn and Fe content in the experimental soil where rice plant has been transplanted are shown in Table 1.

Table 1. Soil analysis of experimental field at 0-30 cm depth

Particulars	Value	Methods
Sand (%)	55	Pipette Method
Silt (%)	27	
Clay (%)	18	
pH	7.62	Glass Electrode pH Meter
EC (mmohs/cm)	1.12	Conductometer
Organic carbon (g kg^{-1})	2.43	Glass Electrode pH Meter
Total N, %	0.243	Modified Kjeldahl Method
OM (%)	4.17	O. M% = 1.72 x O. C%
SAR (%)	12.1	SAR = $Na^+ / (Ca^{2+} + Mg^{2+}/2)^{½}$
ESP (%)	9.5	ESP = Na^+ / CEC
CEC (meq/lit)	21.9	CEC= (mean clay CEC x soil clay %) + (mean humus CEC x soil humus %)
P (ppm)	16	spectrophotometer
K (ppm)	240	flame-photometer
Zn (ppm)	4.8	atomic absorption spectrophotometer
Cu (ppm)	0.5	atomic absorption spectrophotometer
Mn(ppm)	21.4	atomic absorption spectrophotometer
Fe (ppm)	92.2	atomic absorption spectrophotometer

Fe content of the experimental soil (92.2 ppm) was more than critical level (25 pmm) for rice plant healthy growth hence it has not been added in the soil. Texturally it is sandy-loam course textured with low clay content. The experiment was carried out as split-split plot design in randomized complete block with three replications. There were 3 factors in this experiment which are Macro-elements as main plot in two levels (1-control and 2-NPK-fertilizers as basic fertilizer) and sulfur as sub plot in two levels (1-control and 2-S-powder) and Micro-elements as sub-sub plot in five levels (1-control, 2-Zn, 3-Cu, 4-Mn and 5-Zn,Cu,Mn-sulfate fertilizers). Thus, 20 treatments were located in each plot and each of these, were replicated three times (Fig. 1).

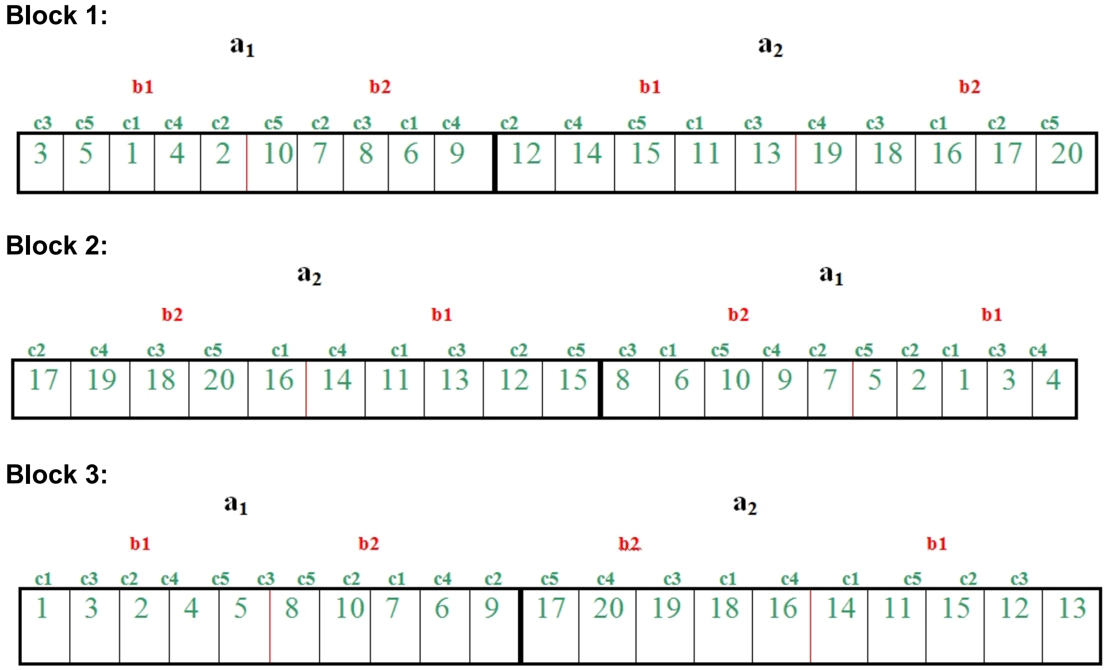

Fig. 1. Divided plots in the experimental field (Layout plan)

Basic fertilizer (NPK-fertilizers), microelement fertilizers and sulfur powder were applied to the plots area as recommended by routine soil analysis [13]. Each plot trampled and mixed with fertilizers in to the soil for balance and perfect distribution of fertilizers. All of the needed elements were counted at the ratio of the experimental field surface (Table 2).

N, P and K-fertilizers were as Urea (50 kg ha^{-1}) with 46% nitrogen, Tripl super- phosphate (50 kg ha^{-1}) with 46% P_2O_5 and potassium sulfate (25 kg ha^{-1}) with 46% K_2O, respectively. Zn, Cu and Mn-fertilizers were as Zn sulfate (30 kg ha^{-1}), Cu sulfate (10 kg ha^{-1}) and Mn sulfate (20 kg ha^{-1}), respectively. The absorbable form of Zn, Cu and Mn by rice plant into the soil areas Zn^{2+}, Cu^{2+} and Mn^{2+}, respectively and their absorbable doses are 50%.Sulfur powder has also been chosen at the rate of 100 kg ha^{-1}. The rice plant seeds sowed on the nursery field after germinating. Afterwards, the rice seedling was transplanted on the selected plots when it was at 15 cm height. Distance of transplanting hill was 25*25 cm and was cultivated 4 stems in each hill. The type of rice variety was Taroom with growth period 90 days, which belongs to the high quality types as Basmati varieties. The field was irrigated and flooded four days after transplanting and other agronomic operations were done by routine and general methods.

Table 2. Scheme of Fertilizer Treatment in the experimental field

Plots	Scheme	Fertilizer treatment
----	-----	**Only micronutrient fertilizers (Commercial great)**
1-	$a_1b_1c_1$	Control, without nutrients
2-	$a_1b_1c_2$	Only Zn SO_4 (30 kg ha^{-1} = 18 g/plot)
3-	$a_1b_1c_3$	Only Cu SO_4 (10 kg ha^{-1} = 6 g/plot)
4-	$a_1b_1c_4$	Only $MnSO_4$ (20 kg ha^{-1} = 12 g/plot)
5-	$a_1b_1c_5$	Zn SO_4 (18 g/plot) + Cu SO_4 (6 g/plot) + Mn SO_4 (12 g/plot)
----	------	**S + Micronutrient fertilizers (Commercial great)**
6-	$a_1b_2c_1$	Only S (100 kg ha^{-1} = 60 g/plot)
7-	$a_1b_2c_2$	S (60 g/plot) + Zn SO_4 (18g/plot)
8-	$a_1b_2c_3$	S (60 g/plot) + Cu SO_4 (6g/plot)
9-	$a_1b_2c_4$	S (60 g/plot) + $MnSO_4$ (12g/plot)
10-	$a_1b_2c_5$	S (60 g/plot) + Zn SO_4 (18 g/plot) + Cu SO_4 (6 g/plot) + Mn SO_4 (12g/plot)
----	-----	**NPK + Micronutrient fertilizers (Commercial great)**
11-	$a_2b_1c_1$	Only NPK (N=urea/50 kg ha^{-1}= 30 g/plot), (P=Super Phosphate/50 kg ha^{-1} =30 g/plot) and (K=Potassium Sulfate/25 kg ha^{-1}=15 g/plot)
12-	$a_2b_1c_2$	Urea (30 g/plot) + Super Phosphate (30 g/plot) + K SO_4 (15 g/plot) + Zn SO_4 (18 g/plot)
13-	$a_2b_1c_3$	Urea (30 g/plot) + Super Phosphate (30 g/plot) + K SO_4 (15 g/plot) + Cu SO_4 (6 g/plot)
14-	$a_2b_1c_4$	Urea (30 g/plot)+ Super Phosphate (30 g/plot) + K SO_4 (15 g/plot) + Mn SO_4 (12 g/plot)
15-	$a_2b_1c_5$	Urea (30 g/plot)+ Super phosphate (30 g/plot) + K SO_4 (15 g/plot) + Zn SO_4 (18 g/plot) + Cu SO_4 (6 g/plot), Mn SO_4 (12 g/plot)
-----	----	**NPK + S + Micronutrient fertilizers (Commercial great)**
16-	$a_2b_2c_1$	Urea (30 g/plot)+ Super Phosphate (30 g/plot) + K SO_4 (15 g/plot) + S (60g/plot)
17-	$a_2b_2c_2$	Urea (30 g/plot)+ Super Phosphate (30 g/plot) + K SO_4 (15 g/plot) + S (60g/plot) + Zn SO_4 (18g/plot)
18-	$a_2b_2c_3$	Urea (30 g/plot)+ Super Phosphate (30 g/plot) + K SO_4 (15 g/plot) + S (60g/plot) + Cu SO_4 (6g/plot)
19-	$a_2b_2c_4$	Urea (30 g/plot)+ Super Phosphate (30 g/plot) + K SO_4 (15 g/plot) + S (60g/plot) + Mn SO_4 (12g/plot)
20-	$a_2b_2c_5$	Urea (30 g/plot)+ super phosphate (30 g/plot) + K SO_4 (15 g/plot) + S (60g/plot) + Zn SO_4 (18 g/plot), Cu SO_4 (6 g/plot), Mn SO_4 (12g/plot)

During the rice plant growth the soil pH was measured at five stages; one week after transplanting, at the maximum tillering stage (30 days after transplanting), at the leaf tube formation stage, at the panicle initiation stage and at the seed maturity stage. Then, the mean or average of soil pH at 5 stages was measured per plot which is shown in the Tables 3 and 4. To measure soil pH, 5-soil samples were collected per plots and mixed and 1 kg of these has chosen to measure soil pH. To determine soil pH, 100 cc distilled water was added to 10 gm of soil sample and mixed. After 24 hours, the pH of soil solution was recorded with pH-meter having temperature compensation adjustment. The agronomic characteristic of rice plant were also measured during the rice plant growth that are the number of tillers per hill at the maximum tillering stage (30 days after transplanting), plant height at panicle initiation stage and seed maturity stage, panicle length, the number of filled grain per panicle, the total number of seed per panicle. After reaching the physiological maturity, the plants were harvested within the central 2 meters of each plot to avoid contamination from the adjacent plot. The harvesting was done at 50 cm height above the soil surface. The combine machine separated the grains, and then 1000-grain weight was calculated. Afterwards, the grain humidity was also measured and brought to the level of 14% humidity and its yield /ha was calculated. Data were analyzed by the analysis of variance technique (ANOVA) and the mean differences were adjudged by Duncans' new multiple range tests (DNMRT) [14]. Microsoft Excel software and also MSTAT-C program has been used for statistical analysis of data.

3. RESULTS AND DISCUSSION

The results showed that the macronutrient fertilizers affected on the plant height at both stages (panicle initiation and seed maturity) and panicle length very significantly. It also influenced on the other agronomic characteristics of rice plant significantly (Table 3). Sulfur powder had very significant influence on total mean soil pH, plant height at panicle initiation and grain yield. It had also significant effect on the plant height at seed maturity stage, the number of filled grain per panicle and the total number of seed per panicle. Table 3 shows that the effect of micronutrient fertilizers was very significant on all the agronomic traits of rice plant except panicle length, total number of seed per panicle and 1000-grain weight. Sulfur powder and micronutrient fertilizers interaction was very significant on mean soil pH, total number of tillers and grain yield. An interaction effect of macro, micronutrient and sulfur powder fertilizers was also significant on plant height at both stages and grain yield. Sulfur powder, macronutrient fertilizers and their interaction affected on the grain yield significantly, while sulfur powder, micronutrient fertilizers and their interaction affected on the grain yield very significantly. According to the obtained results by analysis of variance of data, the most agronomic characteristics of rice plant and its grain yield were statistically influenced using macro, micronutrient and sulfur powder fertilizers, separately or together. It shows that adding the sulfur or sulfate fertilizers into the calcareous soils is effective to reach lower soil pH, higher total number of grain per panicle and finally more rice grain yield. Heydarnezhad et al. [15] reported that the soil pH dropped significantly with the addition of sulfur into the paddy field soils. They suggested that sulfur application is an effective factor for the amendment of calcareous soils. They also suggested that application of sulfur is essential for nutrient availability in calcareous soils.

Table 3. Analysis of variance of macro and micronutrient fertilizers on the measured characteristics at the present study

Treatments	df	Mean soil pH at five stages	Total number of tillers	Plant height at panicle initiation	Plant height at seed maturity	Panicle length	Filled grain per panicle	Total seed per panicle	1000 grain weight	Grain yield
Replication	2	0.003 ns	2.1462 ns	3.5167 ns	3.6932 ns	0.0347 ns	25.867 ns	53.117 ns	0.5962 ns	24043 ns
NPK (a)	1	0.0564*	175.79*	660.02**	734.3**	37.131**	806.67*	576.6*	10.004*	4E+06*
E (a)	2	0.0021	9.2562	0.2167	2.7062	0.3307	22.067	6.45	0.4432	185673
S(b)	1	0.1179**	9.6802 ns	170.02**	15.302*	1.35 ns	166.67*	135*	1.5682 ns	2E+06**
NPK*S	1	0.0003 ns	0.0002 ns	88.817**	47.348**	0.096 ns	96.267*	19.267 ns	1.3202 ns	219736*
E(b)	4	0.0028	4.6662	0.2667	1.8073	0.382	8.7667	9.6833	1.6807	18182
Zn, Cu, Mn (c)	4	0.012**	2.9639**	20.375**	16.965**	1.2748 ns	37.9**	25.358 ns	0.4211 ns	194265**
NPK*Zn, Cu, Mn	4	0.0077**	0.9028 ns	2.5583*	9.0422*	0.4711 ns	9.0833 ns	8.0583 ns	0.2371 ns	32603 ns
S*Zn, Cu, Mn	4	0.0078**	3.2923**	0.3917 ns	3.9402 ns	0.1796 ns	5.4167 ns	4.4583 ns	0.1103 ns	107672**
NPK*S*Zn, Cu, Mn	4	0.01**	0.4747 ns	3.1083*	12.444*	0.3506 ns	7.1 ns	12.392 ns	0.1556 ns	74039*
E (c)	32	0.0017	0.6655	0.8583	3.275	0.5171	7.825	12.942	0.6066	19530
C.V(%)	---	1.12	13.64	3.66	2.75	3.99	4.7	4.2	3.6	10.05

** and ** are significant and very significant at the level of P=0.05 and P=0.01, respectively in F-test. Ns is not significant.*

Table 4 shows that the all used treatments had significant difference on all the agronomic characteristic of rice plant. Mean comparison of data at the present study shows that soil pH at the five stages decreased using macro, sulfur powder and micronutrient fertilizers during plant growth period. This is in agreement with earlier workers by Slaton et al. [16] and Sharma and Swarup [17]. The minimum soil pH is related to treatment no.20 when macro (NPK), micronutrient (Zn, Cu and Mn) and sulfur powder fertilizers applied together. Soil pH decreased 0.35 unit by treatment no. 20 (NPK+S+Zn, Cu, Mn) and 0.32 unit by treatment no. 17 (NPK+S+Zn fertilizers) compared to the control plot. The maximum number of tillers (18.8), plant height (at panicle initiation 124cm and seed maturity stage 164cm) and panicle length (28cm) was obtained by treatment no.20. The all used treatments decreased 1000-grain weight. The minimum of its value was obtained by treatment no. 20 (23.5 g). The number of filled grain (118) and total number of seed per panicle (126) and grain yield (4376 kg ha^{-1}) were reached to the maximum values when macro (NPK), micronutrient (Zn) and sulfur powder fertilizers applied together(treatment no. 17).Rice grain yield was increased 1483 kg ha^{-1} by this treatment compared to the control plot (2893 kg ha^{-1}). It is because of increasing the number of filled grain and total number of seed per panicle at this treatment. On the other hand, the number of tillers per hill and panicle length at treatment no. 17 is the similarly at the level of P=.05 compared to treatment no. 20, statistically. It shows that all of the agronomic characteristics of the rice plant at treatment nos. 17 and 20 are the same values, statistically, except plant height. According to the obtained results, treatment nos. 17 and 20 are the suitable treatments at the present study; but treatment no. 17 (use of NPK+ S + Zn-sulfate fertilizers), can be concluded as the best treatment because the production cost of rice plant will be declined by it because of lack of Cu and Mn fertilizers.

Table 5 shows that the use of Zn, Cu and Mn fertilizers increased grain yield 923kg ha^{-1}. This observation is in agreement with earlier worker by Surajit and Datta [18]. The results showed that by adding only sulfur powder, grain yield increased 873 kg ha^{-1} compared to the control plot. This observation is in agreement with the earlier workers [1,7]. Saadati [19] and Fallah and Saadati [12] showed that 200-400 kg ha^{-1} of sulfur addition increased the rice yield by 500 kg ha^{-1}. Turner [18] has reported that plots treated with sulfuric acid out-yielded those treated with nitrogen and other nutrients. It seems that lowering of soil surface pH from 7.5 to 6.2 raised the rice crop yield by about 1000 kg ha^{-1}. Using NPK fertilizers also increased grain yield 907 kg ha^{-1} compared to the control plot. When NPK and Zn, Cu, Mn fertilizers applied into the soil together, grain yield increased 1163 kg ha^{-1} as compared with control plot and when NPK, S and Zn, Cu, Mn fertilizers applied together, grain yield increased 1400 kg ha^{-1} as compared with control plot. It shows that NPK, sulfur powder and Zn, Cu, Mn fertilizers increases grain yield separately, but when all of those fertilizers use into the soil together, grain yield will be increased significantly. Surajit and Datta [18] had reported that use of NPK fertilizers without addition of Zn decreased the rice yield, while addition of zinc oxide or zinc sulfate increases the yield of rice. It was reported that yield increased by 850 kg ha^{-1}. Malakoti and Tehrani [11] and Fallah and Saadati [12] had also reported that the addition of potassium chloride (as macronutrient), zinc sulfate and copper sulfate as fertilizers revealed that the rice yield increases by 340, 1070 and 600 kg ha^{-1}, respectively. Increasing soil pH retarded growth and tillers of rice. Grain yield reduced to 50% at pH 10.3 but Zn sulfate (15 kg ha^{-1}) in general, raised the yield levels by 1.6 to 2.3, times. Increase in pH caused significant decrease in Zn, Ca, Mg, P and K concentrations in grains. Zinc application, apart from increasing tissue Zn content, elevated Ca: Na and K: Na ratio resulting in improved growth and yield of rice under soil sodic and alkalinity [20].

Table 4. Mean comparison of the effect of macro and micronutrient fertilizers on the measured characteristics at the present study

Treatments	Mean soil pH	Number of tillers	Plant height at panicle initiation/cm	Plant height at seed maturity/cm	Panicle length/cm	Filled grain per panicle	Total seed per panicle	1000 grain weight/gr	Grain yield/ kg ha^{-1}
1-Witness (control)	7.54^{n}	12.5^{o}	110^{i-m}	148^{l}	24.6^{kl}	101^{l}	109^{k}	25.5^{a}	2893^{s}
2-Zn	7.37^{m}	14.5^{hij}	111^{h-l}	153^{e-i}	25.8^{ghi}	107^{f-k}	117^{e-i}	25.0^{ab}	3310^{pq}
3-Cu	7.29^{d-h}	13.9^{j-m}	110^{i-m}	152^{f-j}	25.7^{g-j}	108^{f-j}	116^{e-j}	24.5^{a-d}	3266^{pqr}
4-Mn	7.33^{g-l}	13.8^{j-n}	112^{g-k}	154^{d-h}	25.8^{ghi}	109^{e-i}	118^{d-h}	24.6^{abc}	3420^{p}
5-Zn,Cu,Mn	7.29^{d-h}	14.3^{h-k}	114^{f-i}	155^{d-g}	26.4^{gh}	110^{d-h}	118^{d-h}	24.3^{a-e}	3816^{e-l}
6-S	7.29^{d-h}	15.0^{j}	112^{g-k}	151^{g-k}	25.6^{g-k}	106^{g-l}	116^{e-j}	24.3^{a-e}	3766^{f-o}
7-S+Zn	7.24^{b-d}	15.5^{h}	113^{f-j}	152^{f-j}	25.8^{ghi}	107^{f-k}	118^{d-h}	24.3^{a-e}	3880^{c-i}
8-S+Cu	7.25^{c-e}	14.0^{i-l}	111^{h-l}	151^{g-k}	25.7^{g-j}	108^{f-j}	118^{d-h}	24.3^{a-e}	3840^{d-j}
9-S+Mn	7.28^{d-g}	14.0^{i-l}	113^{f-j}	152^{f-j}	25.5^{g-l}	107^{f-k}	117^{e-i}	23.8^{b-g}	3833^{d-k}
10-S+Zn,Cu,Mn	7.30^{e-i}	14.5^{hij}	114^{f-i}	153^{e-i}	26.7^{b-g}	111^{d-g}	119^{d-g}	24.0^{b-f}	3776^{f-n}
11-NPK	7.31^{f-j}	15.3^{hi}	115^{e-h}	159^{bc}	27.1^{a-f}	110^{d-h}	120^{c-f}	23.6^{b-i}	3800^{e-m}
12-NPK+Zn	7.32^{f-k}	17.8^{a-d}	115^{e-h}	157^{b-e}	27.2^{a-e}	113^{c-e}	121^{b-e}	23.8^{b-g}	4016^{b-g}
13-NPK+Cu	7.27^{c-f}	17.1^{b-g}	115^{e-h}	156^{c-f}	27.1^{a-f}	111^{d-g}	121^{b-e}	23.6^{b-i}	3966^{c-h}
14-NPK+Mn	7.28^{d-g}	17.7^{a-e}	116^{d-g}	158^{bcd}	27.1^{a-f}	112^{c-f}	121^{b-e}	23.6^{b-i}	4016^{b-g}
15-NPK+Zn,Cu,Mn	7.33^{g-l}	18.1^{abc}	117^{def}	157^{b-e}	27.2^{a-e}	114^{b-d}	121^{b-e}	23.7^{b-h}	4056^{b-f}
16-NPK+S	7.23^{bc}	18.2^{ab}	119^{cde}	159^{bc}	27.3^{a-d}	116^{abc}	123^{a-d}	23.6^{b-i}	4100^{b-e}
17-NPK+S+Zn	7.22^{b}	17.6^{a-f}	120^{bcd}	160^{b}	27.2^{a-e}	119^{a}	127^{a}	23.8^{b-g}	4376^{a}
18-NPK+S+Cu	7.22^{b}	17.8^{a-d}	122^{abc}	159^{bc}	27.5^{abc}	118^{ab}	123^{a-d}	23.6^{b-i}	4150^{abc}
19-NPK+S+Mn	7.23^{bc}	17.6^{a-f}	123^{ab}	159^{bc}	27.7^{ab}	118^{ab}	125^{abc}	23.6^{b-i}	4126^{a-d}
20-NPK+S+Zn,Cu,Mn	7.19^{a}	18.8^{a}	124^{a}	164^{a}	28.0^{a}	118^{ab}	126^{ab}	23.5^{c-j}	4283^{ab}

A given means per each column with the same letters, have not significant difference, statistically (P=.05).

Table 5. Mean comparison of macro, sulfur and micronutrient fertilizers on rice grain yield

Treatments	Grain yield (kg ha^{-1})	Increase relating witness
Witness	2893	-----
Zn, Cu, Mn	3816	923
S	3766	873
NPK	3800	907
S+Zn, Cu, Mn	3776	883
NPK+Zn, Cu, Mn	4056	1163
NPK+S	4100	1207
NPK+S+Zn, Cu, Mn	4283	1400

It seems that when sulfur powder and micronutrient fertilizers applied into the soil, yield and yield components of rice plant increases under calcareous soils because of following cases: 1. Decrease soil pH, 2. Increase the solubility of some elements like Zn, Cu, Mn and Fe into the paddy field soils, 3. Increase the availability and uptake of these trace elements by rice plant roots, 4. Increase the uptake of other elements especially N, P, K-elements, 5. The effect and role of the micronutrient elements in photosynthesis processes by increasing the enzymes activities and finally, suitable growth of vegetative (plant height, number of tillers, panicle length) and generation (number of filled grain, and number of seed per panicle) of rice plant which all of those resulted higher grain yield.

4. CONCLUSION

According to the examination and investigation of the present study, using macro- and micro-nutrient and sulfur powder fertilizers into the calcareous soils with high soil pH and calcium carbonate content can be suitable for rice plant healthy growth. It can be concluded that the use of macro- and micro- nutrient fertilizers with sulfur powder together decreases soil pH, increases other elements uptake and increases grain yield. At the present research, treatment no. 17 (using NPK+ S + Zn-sulfate fertilizers together) can be resulted as the best treatment under calcareous soils conditions.

Some of suggestions in this study can be cited as following cases:

1. Soil pH should be measured at several times of rice plant growth and different depth of the soil like surround of the root (Rhizosphere).
2. The element concentration in the rice grain should be measured especially Zn, Cu, Mn and Fe.
3. The effect of different elements should be examined on the other rice varieties under calcareous soils.
4. This research should be repeated at minimum 2 agronomic years.
5. This research should be done at the different places and rain-fed or upland farming systems.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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