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# Effect of Foliar Application of High Concentrations for Some Micronutrients on Growth and Yield of Submergence Rice Grown In Calcareous Soil

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## Abstract

A farmer field trial experiment was conducted at the growth season of 2016 in the Deraluk sub-district, Amadiya district, Dohuk province, Iraq. The purpose of the experiment was to investigate the effect of foliar application of high concentration of some micronutrients on growth and yield of submergence rice (Oryza sativa L.) grown in calcareous soil. Concentration of 0.5% of the micronutrients Fe, Zn, Mn and Fe + Zn + Mn in addition to the control (water) was used as a foliar application in three replications and three splits: The first split was at the beginning of tillering (35 DAS), the second split was just before anthesis (70 DAS) and the third was after full anthesis (100 DAS). The results showed an insignificant increasing in plant heights and the weight of 1000 seeds over the control. In contrast, the number of panicles, except the treatment Fe+Zn +Mn, and the number of seeds per panicle were reduced but not statistically significant compared to the control. The grain yield non-statistically significant increased only for the treatment Fe+Zn+Mn by 2.42% over the control; while the other treatments and the straw yield treatments were non-significantly reduced compared to the control. No significant values of (HI) were found between the treatments despite the superiority of treatments, except Mn, over the control.

**Keywords:** Foliar; Rice; Submergence; Micronutrients

## Introduction

Rice (*Oryza sativa* L.) is the most important cereal grain and widely grown in the world. It grows in a wide range of environments over more than a hundred countries. Yields range from less than 1 t $ha^{-1}$ under very poor rainfed conditions up to more than 10 t $ha^{-1}$ in intensive temperate irrigated systems. Food and Agriculture Organization (FAO) estimated that the total harvest of paddy in 2010 was 701.13 million metric tons (near to 470 million tons of milled rice), harvested from 161.76 million hectares, more than 90% from Asia [1]. An additional 116 million tons of rice will be needed by 2035 to feed growing populations. Rice farming will need to produce about 8–10 million tons more paddy per year over the next decade. Without area expansion, this will require an annual yield increase of about 1.2–1.5%, equivalent to an average yield increase of 0.6 t $ha^{-1}$ world-wide during 2007–2011[2]. The United States Department of Agriculture (USDA) estimates Iraq's rice production (the crop year 2014-2015) at 110,000 metric tons, down 59 percent from 267,000 tons the previous year. Harvested area is estimated at 48,000 hectares, down 50 percent, with rough rice yield at 3.44 tons per hectare, a decrease of 17.7 percent from last year. The lower rice area was attributed to restricted water conditions, mainly associated with dryer weather and low Euphrates river flow [3].

The major yield-limiting factors in soils of arid and semiarid regions are the deficiency of micronutrients. In such regions, soils are characterized by low organic matter, high pH and high $CaCO_3$ [4-6]. These properties of the soil reduce the availability of the mineral nutrients to crop plants [7]. Such kinds of soils are common in the northern part of Iraq and usually known as calcareous soils [8, 9].

The micronutrients play an important role in increasing crop yield. Brown, *et al.* [10] stated that micronutrients can contribute to increasing grain yield up to 50%, as well as increasing of macronutrients use efficiency. Iron Involves role in biological redox system, enzyme activation and oxygen carrier in nitrogen fixation [11]; Zinc is important to membrane integrity and phytochrome activities [12]; Mn utilized in enzyme activation, electron transport and in disease resistance [13]. In calcareous soils, correction of Zn or Fe deficiency is not always easy through the use of Zn or Fe fertilizers because of their extremely poor solubility. Remediation of Zn and Fe deficiencies by fertilizers only is costly and time-consuming management [14].

Foliar feeding, a term referring to the application of essential plant nutrients to above-ground plant parts, has been documented as early as 1844 when an iron sulfate solution was sprayed as a possible remedy for "chlorosis sickness" [15]. In addition to the roots, higher plants can also uptake the nutrients through the green parts, especially the leaves. Researches showed that the nutrient passes through the cuticle, cell wall and the membranes, leaves stomata's and ectodesmata [16-22]. It's more effective to control deficiency problem under certain circumstances than soil application [23-31]. Foliar application of micronutrients has been widely used in many studies and had obvious effects on the growth and yield of crops. For example, with rice crop [32,33]; with wheat [34-40]; with corn [41-43]; with okra [44,45]; with sunflower [46]; with soybean and with flax [47,48].

The purpose of the experiment is to investigate the effect of foliar application of high concentration of some micronutrients on growth and yield of submergence rice (*Oryza sativa* L.) grown in calcareous soil.

# Materials and Methods

## Field Location and Soil Characters

Farmer field trial experiment was conducted at the growth season of 2016 in the Deraluk sub-district (the field area was 1536 $m^2$ and GPS location: 38˚06"61'N; 41˚00"79' E; elevation: 663m), Amadiya district, Dohuk province, Iraq. An appropriate soil sample was taken from the depth of 0.3m, air-dried and required chemical and physical properties were determined.

## Land Preparation and Sowing

The land was plowed perpendicularly and horizontally, flooded with water, mixed well till becoming muddy and divided into ununiformed plots according to the land topography to ensure the submergence conditions along the growth season. Fifteen plots from the beginning, middle and end of the field were chosen. Dry seeds of local rice cultivar (named "short retik" has a short stalk and have no or very small awn) was sown at a rate of 100 kg $ha^{-1}$ via hand broadcasting method on May $14^{th}$, 2016. The weeds controlled chemically 36 days after sowing (DAS), the plots were dried 4 days before spraying the herbicide and flooded again 2 days after using the herbicide.

## Fertilization

Basal organic fertilizer (cow dung) was added to the soil at the amount of 5.860 t $ha^{-1}$; also two doses of nitrogen fertilizer were added at a rate of 40 kg N $ha^{-1}$ for each dose, the first was with seeds and the second at active tillering. One time soil application of phosphorus fertilizer at a rate of 60 kg $P_2O_5$ $ha^{-1}$ was added with seeds.

## Treatments Application

Concentration of 0.5% of the micronutrients Fe, Zn, Mn and Fe + Zn + Mn in addition to the control (water) was used as a foliar application in three replications and three splits: The first split was at the beginning of tillering (35 DAS), the second split was just before anthesis (70 DAS) and the third was after full anthesis (100 DAS). The knapsack sprayer of 8 litter's capacity was used and spraying time was at about two hours before sunset. The spraying was stopped just after the solution starting to flow over the shoots.

## Harvesting

The crop was harvested on October $12^{th}$, 2016. One square meter was chosen from each treatment, the plants were cut near the soil surface and the growth parameters were taken, then the whole plant has been threshed, the paddy was refined and both straw and grain yields were calculated based on air-dry weight. The harvest index (HI) is the ratio of harvested grain to total shoot dry matter, and this can be used as a measure of reproductive efficiency. It has been calculated from the equation below:

HI= Grain yield/biomass.

## Statistical Analysis

A randomized complete block design (RCBD) was used for the statistical analysis of the data. The treatment means were compared by determining the least significant difference (LSD) at 5% level of probability (P=0.05) using statistical analysis software SAS [49].

# Results and Discussion

## Soil Properties

The soil was clayey (30.9, 23.75 and 45.35% sand, silt and clay respectively) with a bulk density of 1.67 $Mgt^{-1}$, pH of 7.58, EC of 0.24 Ds $m^{-1}$, organic matter of 12.0 g $kg^{-1}$, CEC of 18.89 Cmolec $kg^{-1}$. Available N and P were: 140 and 8 ppm respectively. Available dissolved ions (1:10 soil: water suspension) were: 0.14, 0.19, 3.05, 1.31, 0.15, 1.35 and 0.6 *meq* $L^{-1}$ for $K^+$, $Na^+$, $Ca^{++}$, $Mg^{++}$, $CO_3$=, $HCO_3$= and $Cl^-$ respectively. Available micronutrients were: 3.58, 0.49, 6.36 and 2.85 ppm for Fe, Zn, Mn and Cu respectively.

The clayey soil is good media for submergence rice but the somewhat high alkaline cations and pH conditions with low organic matter are the basic reasons for lowering the availability of the studied micronutrients and in turn the yield.

## Plant Parameters

Concerning the plant heights and the weight of 1000 seeds (table-2), there was an increase in the studied parameters over the control but was not statistically significant. The increasing ratio of the treatments as compared to the control respectively for Fe, Zn, Mn and Fe+Zn +Mn was as follows 3.23, 2.26, 3.78 and 4.16% for the plant heights and 2.92, 1.46, 0.51 and 6.95% for the weight of 1000 seeds. In contrast, the number of panicles, except the treatment Fe+Zn +Mn, and the number of seeds per panicle were reduced but the values were not statistically significant compared to the control.

The grain yield for the treatment Fe+Zn+Mn increased by 2.42% over the control but this increment was not statistically significant; While the other treatments were reduced non-significantly as compared to the control by 7.29, 5.44 and 17.51 % respectively for Fe, Zn and Mn. The straw yield has no-significant reduction compared to the control. The reduction ratio was 13.80, 14.12, 7.99 and 0.12% respectively for Fe, Zn, Mn and Fe+Zn +Mn. No significant values of (HI) were found between the treatments despite the superiority of treatments, except Mn, over the control.

The addition of the studied micronutrients with this relatively high concentration when sprayed individually as a foliar application on the green parts had disadvantages on both grain and straw yields although it is insignificantly increased the plant heights and 1000-grain weights; it lowered the number of both panicles and seeds per panicle that reflexed on the yield. This reduction may refer to the starting of the toxicity effects of the surplus addition of these micronutrients. The plants were susceptible to Mn more than Fe and Zn. The hypoxic condition in the root zone of submergence rice is a favor to activate the dissolution of such metals to the soil solution which in turn leads to increasing the uptake. So, the oversupply of one of these metals on the account of the others will alter the competitive balance between these elements in the absorption sites by increasing the uptake of such metal and/or blocking the uptake of the others then shift the balance toward the increased metal. This phenomenon is called "antagonism"; it is frequently reported in the literature [47, 50-54]. For example, Pathak, *et al* [50]. Reported a positive interaction between $Fe^{+2}$ and $Mn^{+2}$ when applications were balanced but imbalance led to high levels of one element depressing uptake of the other elements when the latter was applied at a low level [55]. Similarly, Chaudhry and Wallace reported that Fe completely inhibited Zn absorption by rice and Marschner indicated to $Fe^{2}$ deficiency when $Mn^{2}$ oversupplied. The antagonism occurs not in soil solution and on root absorption sites only, but may also impair the translocation of the metals inside the plant [54]. The combined spraying of these elements may make the balance somewhat stable and lower the antagonistic effect. This probably explains the increase of the yield in the case of the treatment Fe+Zn+Mn [57]. Similar findings were reported by Zayed, *et al*., they found that the combined foliar application of $Zn^{+2}$ +$Fe^{+2}$ + $Mn^{+2}$ gave the highest non-significant values of most studied traits of rice compared to the single application of each of these elements.

| Treatment | Plant height (cm) | No. of panicles per ($m^2$) | No. of seeds in panicle | 1000 seeds weight (g) | Grain yield (Mg $ha^{-1}$) | Straw yield (Mg $ha^{-1}$) | Harvest Index (HI %) |
|---|---|---|---|---|---|---|---|
| Control | 88.33 | 292.22 | 137.22 | 27.33 | 7.54 | 8.64 | 46.60 |
| Fe | 91.00 | 276.64 | 103.00 | 28.40 | 6.99 | 7.51 | 48.22 |
| Zn | 90.33 | 257.39 | 112.78 | 27.73 | 7.13 | 7.42 | 49.00 |
| Mn | 91.67 | 271.07 | 96.33 | 27.47 | 6.22 | 7.95 | 44.00 |
| Fe+Zn+Mn | 92.00 | 302.48 | 103.67 | 29.23 | 7.72 | 8.63 | 47.18 |
| LSD | 6.73 | 55.79 | 69.63 | 3.71 | 6.43 | 5.13 | 9.04 |

**Table 1:** Effect of Fe, Zn, Mn and Fe+ Zn +Mn as a foliar application on growth and yield of submergence rice

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