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RESPONSE OF WHEAT TO FOLIAR APPLICATION OF MICRONUTRIENTS IN NORTHERN SUDAN

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Abstract: Foliar sprays are widely used to apply micronutrients for many crops. The advantage of the technique is the direct uptake of nutrients into the metabolism of the plant tissues which will in turn, asses the availability of nutrients to crops for obtaining higher yield. This experiment was conducted to study the response of wheat (*Triticum aestivum L.* var. Ammam) yield and yield components to foliar application of micronutrient mixture for two successive seasons (2006/07 and 2007/08) in the farm of the Faculty of Agriculture, Nile Valley University, Darmali, Northern Sudan. The experiment was arranged in a randomized complete block design with three replications. Treatments consisted of six rates (0, 4, 6, 8, 10 and 12 kg/ha) of a mixture of micronutrients (Mn 6%, Cu 2.4%, Zn 3.0% and Fe 1.6%). Parameters recorded included: spikes/m^2, spike length (cm), biological yield/m^2, grain weight/spike, harvest index, 1000-kernel weight and seed yield per unit area. Significant increases in number of spikes/m^2, biological yield, grain weight/spike, harvest index, 1000-kernel weight and grain yield of wheat were obtained as a result of micronutrient foliar application.

The results of this work revealed that high wheat yield and yield components could be obtained by the foliar application of micronutrient at the rate of 8-10 kg/ha at the research site and that the maximum biological yield, harvest index, 1000-kernel weight and grain yield were achieved by the same foliar application at the rate of 10 kg/ha.

Keywords: wheat, foliar application, micronutrients, yields.

Introduction

Wheat (*Triticum aestivum L.*) represents the second most important cereal crop in Sudan after sorghum. The role of macro and micronutrients is crucial in crop nutrition and thus important for achieving higher yields. Micronutrients, such as Mn, Fe, Cu, Zn, B and Mo are required for all higher plants and apparently involved in photosynthesis, nitrogen fixation, respiration and other biochemical pathways (Welch *et al.* 1991). According to George and Sims (2006); Modaihsh (1997) and Jahiruddin *et* *al.* (1995), the grain yield was significantly enhanced by the application of micronutrient combinations and the resultant biological and grain yields were higher than when applying individual micronutrients. Wheat responses to micronutrient applications followed in rank order: combined elements Fe, Cu, Zn and Mn.

The soil nutrient content may not be always enough to fulfill crop requirements. Most of micronutrients, such as Fe and Mn are readily fixed in soil having alkaline pH. Plant roots are unable to absorb these nutrients adequately from dry topsoil (Foth and Ellis, 1996). Further, availability of micronutrients like Cu, Zn and Mn may be reduced under high pH conditions which are common in most wheat growing areas in Sudan. The approach of applying micronutrients by foliar technique has been reported to be more effective than soil application by different researchers (Abdalla *et al.* 1994; Torun *et. al.,* 2001 and El Fouly et *al.* 2007). They documented the benefits of foliar application in lowering the negative effects of micronutrients deficiency in soil. Ibrahim (1990) applied a foliar mixture of Zn. Fe and Mn on wheat grown at the Karu soil of Northern Sudan, and concluded that such treatment increased the yield by more than 15% over the control. In a different study, it was observed that grain yield increased by 39% when higher rates of Cu or Mn were applied to wheat crop (Abdalla *et al.* 1993). El-Magid, *et al.* (2000) found that spraying wheat with Fe, Zn, Mn or B increased shoot height and the number of tillers per plant and Fe, Cu, Zn and Mn increased grain and straw yields, while B increased only the straw yield. Ziaeian *et al.* (2001) observed an increase in wheat grain yield, 1000- kernel weight and seed number per spikelet in calcareous soils with the application of Fe, Mn, Zn, and Cu in chelated forms.

The high terrace soil of the River Nile State is an infertile sandy soil and occasionally suffers from salinity and/or sodicity hazards. It occupies large areas and future expansion in agricultural production has to utilize this type of soil (Ibrahim, 1996). The objective of this study is to investigate the effect of micronutrients foliar application on yield and yield components of wheat and hence, to determine the optimum dose to be applied under the conditions of Northern Sudan.

Materials and Methods

Field experiments were conducted at the Faculty of Agriculture Farm, Nile Valley University, Darmali, Northern Sudan (latitude 17°48 N, longitude 34° 00E and altitude 346.5 meter above sea level) during the 2006/07, 2007/08 growing seasons The experimental soil can be described as calcareous matrix strongly alkaline with low permeability to water and low in nitrogen and humus contents (Table 1).

The experiment was arranged in a randomized complete block design with three replications. The treatments consisted of six rates (0, 4, 6, 8, 10 and 12 kg/ha) of a combination of (Mn 6%, Cu 2.4%, Zn 3.0% and Fe 1.6%) micronutrients applied in two equal splits, at tillering and elongation stages.

The Land was prepared by disc plough and disc harrow, leveled and ridged. Wheat variety Ammam was sown at the rate of 100 kg/ha on the 1st of Nov. 2006 in the first season and on 9th of Nov. 2007 in the second season. The plot size was 10×3 m and with 10 rows. The crop was irrigated every 10 days. Urea as source of nitrogen was applied at the rate of 48 kgN/ha in two splits, half at tillering and the remaining half at elongation stage. The crop was kept free of weeds throughout the growth period by hand weeding.

At physiological maturity, ten plants were randomly selected from harvest area, at the six centered rows of each plot leaving 1m from both ends of the plots as belt, to measure the number of spikes per square meter, spike length, dry weight per square meter, grain weight/ spike, harvest index, 1000-kernel weight and grain yield per unit area (kg/ha).

The data were subjected to the analysis of variance to test the significance of treatment effects. Duncan's Multiple Range Test was used to compare treatment means using the computer program MSTAT-C (MSTAT-C, 1991).

Results and Discussion

Number of spikes

Data presented in Table (2), indicate that foliar application of micronutrients significantly ($p \leq 0.05$) increased the number of spikes/m^2. Maximum number of spikes/m^2 was produced (344 - 340) by treatments of 8 - 10 kg/ha, respectively. While minimum number of spikes/m^2 was produced (220) by the control treatment (0 kg/ha). These results are in agreement with the findings reported by Soylu *et al.*, (2005) and Kenbaev and Sade (2002)

Spike length

Spike length was not affected by the different foliar application rates of micronutrients (Table 2), which may be attributed to varietal characteristics.

Biological yield

Data presented in Table (2), indicate that the biological yield was significantly ($p \leq 0.05$) affected by the tested foliar application rates of micronutrients. The maximum and the minimum biological yield were produced (1811 and 620 g/m^2) by treatments of 10 kg/ha and control (0 kg/ha),

Table (1): Chemical and Physical properties of soil in experimental site

Determination	
PH	8.8
EC (mmho/cm)	0.38
Sand (%)	20.1
Silt (%)	21.3
Clay (%)	58.6
Organic carbon (%)	0.203
Extractable N (ppm)	278
Extractable P (ppm)	2.3

Table(2): Effect of foliar application of micronutrients on number of spikes, spike length and biological yield of wheat (average of two seasons).

Micronutrients rate (kg/ha)	Number of Spikes/m^2	Spike length (cm)	Biological yield (g/m^2)
0	219.50[b]	11.00[a]	619.7[b]
4	268.83[b]	11.83[a]	725.2[ab]
6	235.17[b]	11.50[a]	843.8[ab]
8	343.50[a]	11.67[a]	937.5[ab]
10	339.83[a]	12.17[a]	1810.7[a]
12	229.67[b]	12.00[a]	702.7[ab]

Means with the same letters are not significantly different according to Duncan's Multiple Range Test

respectively. These results are in agreement with previous research reports by Torun *et al* (2001); Sadana *et al,* (2002) and Soleimani (2006). El-Magid, *et al.* (2000) noticed an increase in straw yields by the foliar application of micronutrients Fe, Cu, Zn and Mn.

Grain weight per spike

Data presented in Table (3) showed that the grain weight per spike was significantly ($p \leq 0.01$) affected by the foliar application rates of micronutrients. The maximum and the minimum grain weight per spike were produced (0.87 and 0.53 g) by treatments of 8 kg/ha and control (0 kg/ha), respectively.

Harvest index

Foliar applied micronutrients significantly ($p \leq 0.05$) affected this variable (Table 3). The maximum and the minimum values of harvest index (30.48 and 18.23) were produced by treatments of 10 kg/ha and control (0 kg/ha), respectively. Similar results were reported by Abdalla *et al.* (1993).

1000-kernel weight

1000-kernel weight was significantly ($p \leq 0.001$) affected by the foliar application of micronutrients (Table 3). The maximum and the minimum 1000-kernel weight (5.67 and 3.33) were produced by treatments of 10 kg/ha and control (0 kg/ha), respectively. These results are in accordance with those obtained by Geuenis *et al.*, (2003) and Soylu *et al.*, (2005) who recorded a significant increase in 1000-kernel weight with micronutrients foliar application.

Grain Yield

Grain yield (kg/ha) showed significant ($p \leq 0.01$) increase by foliar applying micronutrients in both seasons (Table 4). All treatments produced higher grain yield (values ranged from 1117 to 2385 kg/ha) over control (0 kg/ha). The wheat grain yield was increased significantly with the increasing foliar application rates from 4 to 10 kg/ha. The beneficial effects of foliar fertilization of micronutrients in increasing wheat grain yield may be attributed to copper and zinc (Saif, et al. 1997). The highest rate of foliar application gave the highest grain yield percentages (63%) more than the control. This might be attributed to grain weight per spike, harvest index and 1000- kernel weight. Maximum and minimum grain yield (2385 and 1117 kg/ha) were produced by the treatments of 10 kg/ha and control (0 kg/ha), respectively. These results are in harmony with the findings of Ibrahim (1990); Modaihsh, (1997); Torun *et al*, (2001) and George and Sims (2006).

It can be concluded that wheat crop positively responded to the applied of micronutrient foliar mixture at the rate of 8-10 kg/ha by giving maximum grain yield per unit area.

Table(3): Effect of foliar application of micronutrients on grain weight/spike, harvest index and 1000-kernel weight of wheat (average of two seasons).

Micronutrients rate (kg/ha)	Grain wt. per spike	Harvest index	1000-kernel weight (g)
0	0.53[c]	18.23[c]	20.5[d]
4	0.63[bc]	19.20[c]	26.6[c]
6	0.67[bc]	25.49[abc]	28.8[b]
8	0.87[a]	28.01[ab]	26.5[c]
10	0.72[ab]	30.44[a]	31.3[a]
12	0.59[bc]	22.48[bc]	25.2[c]

Means with the same letters are not significantly different according to Duncan's Multiple Range Test

Table (4): Effect of foliar application of micronutrients on grain yield of wheat of the two seasons.

Season … Micronutrients rate (kg/ha)	2006/07	2007/08	Mean
0	1204[d]	1030[c]	1117[d]
4	1437[c]	1205[c]	1321[cd]
6	1542[c]	1524[c]	1533[bcd]
8	1803[b]	2573[ab]	2188[ab]
10	1994[ab]	2776[a]	2385[a]
12	2189[a]	1759[bc]	1974[abc]
Mean	1695[a]	1811[a]	

Means with the same letters are not significantly different according to

Duncan's Multiple Range Test.

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استجابة القمح للرش بمخلوط المغذيات الصغرى في شمال السودان

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أجريت هذه الدراسة خلال موسمي07 /2006 و 08 /2007 بمزرعة كلية الزراعة، جامعة وادي النيل، بدار مالي، شمال السودان، هدفت هذه الدراسة لمعرفة استجابة صنف القمح (إمام) للتسميد الورقي بمخلوط المغذيات الصغرى (1.6% Fe , 3.0% Zn , 2.4% Cu , 6% Mn) و لتحديد المعدل المناسب للتسميد الورقي باستخدام ستة معدلات (٠، ٤، ٦، ٨، ١٠ و١٢ كجم/هـكتار). القياسات التي تمّ دراستها شملت: عدد السنابل في المتر المربع، طول السنبلة، وزن المادة الجافة في المتر المربع ، وزن الحبوب في السنبلة، دليل الحصاد، وزن الألف حبة و ومحصول الحبوب في وحدة المساحة

أوضحت النتائج استجابة محصول القمح للتسميد الورقي بالمغذيات الصغرى حيث ادي إلى وجود زيادة معنوية في عدد السنابل في المتر المربع، وزن المادة الجافة في المتر المربع، وزن الحبوب في السنبلة، دليل الحصاد، وزن الألف حبة و المحصول من الحبوب في وحدة المساحة بينما لم يتأثر طول السنبلة بالمعدلات المختبرة. وأعطى معدل التسميد الورقي بالمغذيات الصغرى ١٠ كجم/هـكتار اعلي محصول من الحبوب(٢٣٨٥ كجم/ هـكتار) وبزيادة قدرها ٦٣% مقارنة بالشاهد.

وقد أسفرت النتائج عن استجابة واضحة لمحصول القمح للتسميد الورقي بمخلوط المغذيات الصغرى وأمكن الحصول على أعلى محصول من الحبوب باستخدام معدل ٨- ١٠ كجم/ هـكتار تحت ظروف أراضي التروس العليا بشمال السودان.