AGRONOMIC EFFICIENCY OF Zn-DTPA AND BORIC ACID FERTILIZERS APPLIED TO CALCAROUS IRAQI SOIL

NOORULDEEN.S. ALI
Professor
shawqiali@yahoo.com

BAYDAA .H. A. Al-AMERI**
Scientific Researcher
Baydaa.2012.@yahoo.com

COLLEGE OF AGRICULTURE, UNIVERSITY OF BAGHDAD

ABSTRACT

Field experiment was conducted to investigate the impact of zinc and boron on productivity of maize (Zea *mays* L.) grown in an alluvial calcareous Iraqi soil. Treatments included two levels of Zn (0, 10 kg Zn ha^{-1}) added as Zn-DTPA to soil and three levels of B (0, 0.5, and 1.0 kg B ha^{-1}) added either completely to soil or 90% to soil and 10% as foliar application during growing period in a split-split plot trial with three replicates. Results indicated that the application of Zn, B, and Zn+B had significant effect on yield of maize, agronomic efficiency, Zn and B availability at harvest stage. Zinc application as Zn-DTPA (10 kg Zn ha^{-1}) increased grain yield from 6.93 to 9.50 Mg ha^{-1} with an increment of 37.1%. Agronomic Efficiencies were 43.6-69.7 kg grain kg^{-1} Zn-DTPA applied. Application of boron as boric acid increased grain yield from 7.43 to 8.21 and 9.01 Mg ha^{-1} yield for 0.5 and 1.0 kg B ha^{-1} with an increment of 10.6 and 21.4% respectively. Agronomic Efficiency was in the range of 130-285 kg grain for each kg boric acid applied. These results clearly show the response and economic justification for Zn and B applications for such crop and soil conditions. Soil Zinc and B availability at harvest stage of maize was affected significantly by zinc and B applications. This mean that soil fertilized adequately with Zn-DTPA and Boric acid can be considered as soil with fairly adequate Zn and B for next crop.

Key Words: Fertilizers productivity, Maize (Corn), Residual Zn and B.

***Part Of Dissertation Of The 2[ND] Author**

****PRESENT EDDRES: MINISTRY OF SCIENCES AND TECHNOLOGY-Directorate of Agriculture Research.**

مجلة العلوم الزراعية العراقية – 46(6): 1117- 1122 /2015 علي و علوان

الكفاءة الحقلية لسمادي الزنك المخلبي وحامض البوريك المضافة الى تربة كلسية *

نورالدين شوقي علي
استاذ

بيداء حسن علوان **
باحث علمي

كلية الزراعة–جامعة بغداد

المستخلص

نفذت تجربة حقلية لدراسة التأثير المتداخل للتسميد بالزنك والبورون في انتاجية الذرة الصفراء المزروعة في تربةٍ كلسية رسوبية من العراق. تضمنت المعاملات مستويين من الزنك (0 و 10 كغم Zn هـ$^{-1}$) اضيفت الى التربة وثلاثة مستويـــات من البورون (0 و 0.5 و 1.0 كغم B هـ$^{-1}$) اضيفت اما 100% الى التربة او 90% الى التربة و 10% رش ورقي بإستعمال الزنك المخلبي Zn-DTPA و حامض البوريك مصادراً سمادية بالترتيب بتجربة الواح منشقة– منشقة مع ثلاث مكررات. بينت النتائج وجود تأثير معنوي لإضافة الزنك او البورون وتداخلاتها في في إنتاج إلذرة الصفراء وفي الكفاءة الحقلية للسمادين وفي الزنك والبورون الجاهزة في التربة عند مرحلة الحصاد (الزنك والبورون المتبقية). إضافة الزنك بشكل Zn-DTPA (10 كغم Zn هـ$^{-1}$) زاد من إنتاج حاصل الحبوب من 6.93 الى 9.5 ميكاغرام هـ$^{-1}$ وبنسبة زيادة 37.1% .الكفاءة الحقلية كانت بالمدى 43.6 الى 69.7 كغم حبوب كغم سماد الزنك المخلبي . إضافة البورون بشكل حامض البوريك زاد حاصل الحبوب من 7.43 الى 8.21 و9.01 ميكاغرام هـ$^{-1}$ للمستويين 0.5 و1.0 كغم B هـ$^{-1}$ بالترتيب وبنسب زيادة 10.6 و21.4%. الكفاءة الحقلية كانت في المدى 130-285 كغم حبوب لكل كغم من سماد حامض البوريك . هذه النتائج تبين الإستجابة للتسميد والجدوى الاقتصادية لإضافة البورون والزنك في ظروف التجربة الحالية. جاهزية الزنك والبورون إزدادت عند مرحلة الحصاد و تأثرت معنوياً بالتسميد بالزنك والبورون المضافة. هذه النتائج تشير الى ان التربة المسمدة بمستوى جيد ومصدر سمادي جيد من الزنك والبورون يمكن ان تعد تربة ذات محتوى جيد للمحصول اللاحق.

الكلمات المفتاحية : إنتاجية السماد، الذرة الصفراء، الزنك والبورون المتبقي .

*مستل جزئياً من اطروحة الباحث الثاني .

** العنوان الحالي وزارة العلوم والتكنلوجيا –دائرة البحوث الزراعية

INTRODUCTION

Agronomic efficiency (fertilizer productivity or economic efficiency) can be defined as the increase in crop yield in response to the amount of fertilizer applied (kg crop yield increase per kg fertilizer applied). Many factors can affect such efficiency such as crop, soil, climatic conditions and the quality and quantity of fertilizer applied. Nutrients not used by the crop either lost by retention by soil minerals or are at risk of loss to the envir - onment, especially when fertilizers are applied at rates above agronomic need. In addition, agronomic efficiency can be used as a base for economic and environmental efficiency (8) Applying micronutrients in most cases affe - cted by sorption-precipitation reactions in calcareous soils, therefore its availability decline within short time (6, 7, 9, and 19). Chelated fertilizers can improve this bioava - ilability of micron- utrients such as Zn, and in turn contributes to the productivity and profitability of commercial crop production (6, 7, and 9). Zinc deficiency is very common in many agricultural crops especially on high-pH soils. Sillanpaa (6,25,26) , indicated that Iraqi soils can be consider as among soils which have low Zn availability and most crops especially cereals show Zn deficiency. Boron is an essential micronutrient for plants' devel - opment, growth, crop yielding and seed development, It helps with the transfer of water and nutrition in plants (5, 13, and 17). Though plants' boron requirements are very low in quantity, their growth and crop yields are severely affected when soil is boron deficient. Ranges between deficient and toxic B concentration are smaller than for any other nutrient element (1, 15). Boron deficiency is much more common in crops that are grown in soil that have higher amount of free carbonates, low organic matter, and high pH (19,22).Field research in Iraq has demon - strated yield response to B application to dicotyledonous crops (5, 12,and18). Although, cereals including maize, generally less sensitive to B deficiency than dicoty -ledons, it still affected by deficiency in several parts of the world (23).Boric acid is commonly used in the agriculture industry as a source of boron for solid and liquid fertilizers and can be used for soil and foliar appli ations. hysicochemical behavior of Zn-DTPA and boric acid in soil materials indicated that the soil had high capacity for Zn with low bonding energy and moderate B capacity with low bonding energy which indicates the ability of such soil to release Zn and B (2). There are growing evid - ence related to the positive interaction between Zn and B particularly on plant growth and yield where zinc mitigate boron toxicity thro - ugh its effect on cell membrane integrity (11). Therefore, the undergoing research was under -taken to evaluate effects of boron and zinc fertilizer application and their agronomic efficiencies as related to corn (maize) productivity.

Materials and Methods: A field experiment was conducted at The ministry of Science and technology Al-Jaddiriya farm –Baghdad, Iraq planting maize (corn) (*Zea mays* L.), during 2011 summer cropping season on Typic Torrio -rthent (Entisol) (24). Composite surface soil samples (the site was quite homogenize) were collected from surface horizon(0− 0.3 m) of the soil before the experiment was initiated, air-dried, passed through a 2- mm sieve and analyzed for some chemical and physical soil properties(Table 1). The experiment was split – split plot design distributed according to CRBD. Treatments included 2 levels of Zn (0, and 10 kg Zn ha^{-1} added to the soil as Zn – DTPA (22.7%Zn) prepared by authors and three levels of B(0.0,0.5,1.0 kg B ha^{-1})using boric acid(13% B) , applied either 100% to soil or 90% to soil +10% as foliar . Compound fertilizer (20-20-20+Micronurients) applied in 100 kg ha^{-1} level to all experiment units as starter at planting in band application. In addition , Nitrogen, P and K were applied two weeks after germination in band application too, at 250 N,80 P and 150 kg K ha^{-1} accor - ding to the recommendation, using DAP (18-46-0), urea(46% N)and potassium sulfate (41.5% K), respectively, were added to all treatments. Soil application of Zn and B was made at seeding and foliar application (0.5% zinc sulfate and 0.3% boric acid) at two times: one at vegetative growth stage and the other after corn ears formation. Zinc and B solid fertilizers were both mixed and applied with NPK fertilizers. All agronomic practices (i.e. furrow preparation, seed sawing, irrigation, and weed control) described previously in Al-

Ameri et al., (2).Available Zn Was extracted by 0.005M DTPA + $CaCl_2.2H_2O$+0.1 *M* TEA at pH 7.3(20) and determined by AAS. Available B was extracted by hot water and determined by Ion Couple plasma(ICP) (3). Maize grain productivity and agronomic efficiency were evaluated at the end of the trial using equations mentioned by Ali (8). Standard analysis of variance techniques were used to assess the significance of treatment means(24).

Table 1. Soil chemical and physical properties

property	unit	Value
pH(1:1)	-	7.4
ECe(1:1)	dSm^{-1}	1.3
Organic matter	$g\ kg^{-1}$ soil	4.2
Carbonate minerals		250
CEC	$Cmole_+ kg^{-1}$ soil	11.3
Available N (NH_4-N + NO_3-N)	$mg\ Kg^{-1}$ soil	20.5
Available K		153
Available P		13.2
Available Zn		1.0
Available B		1.9
PSD		
Sand	$g\ kg^{-1}$ soil	202.6
Silt		428.7
Clay		368.7
Texture		loam
Methods described by Black, (1965) and Page et al ,(1982)		

<u>Results and Discussion</u> Data presented in Table 1. Indicates that the soil available K, P and Zn were low, while B was moderate according to Bashoor et al., (14). Table 2 show the effect of Zn and B application on grain yield. Zinc application as Zn-DTPA increased grain yield from 6.93 to 9.50 Mg ha^{-1} with an increment of 37.1%. Fertilizer productivities were 43.6-69.7 kg grain kg^{-1} Zn-DTPA applied (overall different rates of boric acid). Appli - cation of boron as boric acid increased grain yield from 7.43 to 8.21 and 9.01 Mg ha^{-1} yield for 0.5 and 1.0 kg B ha^{-1} with an increment of 10.6 and 21.4% respectively. Fertilizer produ - ctivity was in the range of 130-285 kg grain for each kg boric acid applied (for different rates of boron and zinc. These results clearly show the response and economic justification for Zn and B applications for such crop and soil. The response of maize to boron appli - cation occurred in spite of the low requirement for such crop to boron (16) and this can attributed to low available zinc and to soil properties in general (Table 1). Vitosh et al., (29) believe that B uptake is negligible in calcareous soils with high pH, so that disturbance in pollination process and abortive plants are the common features of such circumstances unless B applied as fertilizer. The highest grain yield was produced by plants that received soil application of 10 kg Zn ha^{-1} and soil + foliar spray of B. The response of corn to Zn application is well documented in the Iraqi literature although for different soil and maize varieties (4,9). This response indicates that the Zn and B available in the studied soil did not meet the crop requirement even for crop with low require - ement for B such as corn plant. The effect of Zn-B interaction on yield parameter was synergetic (Table 2) . This results at the same trend with other investigators who mentioned that the interaction was synergistic on plant growth and yield (11). Fertilizer productivity were 67.5 kg grain for each kg of Zn-DTPA applied and 379.7 kg grain for each kg of boric acid applied .This productivities justify such application with high return, especially for boron. The response of maize to boron appli - cation signifies the role of boron in maize productivity. Boron applied to soil had good results due to the properties of the soil under study which had good capacity for boron and good supplying power for such nutrient as indicated by the laboratory results of Al-Ameri et al (3), for the same soil .Results of this trial were at the same trend with Ziaeyan and Rajaie ,(30) results .It can be seen from their

results that fertilizer productivity (agronomic efficiency) was 57 kg grain to each kg of fertilizer applied and 101 kg grain to each kg of boric acid applied. The differences in the results can be attributed mainly to differences in soils and fertilizer sources used.

Table 2. Effects of Zn and B application on grain yield.

Levels of Zn applied (kg ha^{-1})	Levels of B applied (kg ha^{-1})	Method of B application	Grain yield (Mg ha^{-1})
0	0	90% soil+10% foliar	5.93
	0.5		6.69
	1.0		8.06
	0	100% soil	5.95
	0.5		6.81
	1.0		8.14
10	0	90% soil+10% foliar	8.85
	0.5		9.66
	1.0		9.85
	0	100% soil	8.97
	0.5		9.69
	1.0		10.00
LSD0.05 for Zn levels, B levels, Methods of application and interaction were 0.841, 0.714, NS and 1.427, respectively.			

Table 3. Effects of Zn and B application on Agronomic Efficiency

Levels of Zn applied (kg ha^{-1})	Levels of B applied (kg ha^{-1})	Method of B application	Agronomic Efficiency (kg grain kg fertilizer)	
			Due to B application	Due to Zn application
0	0	90% soil+10% foliar	-	——
	0.5		197.6	
	1.0		276.9	
	0	100% soil	-	
	0.5		223.6	
	1.0		284.7	
10	0	90% soil+10% foliar	-	43.6
	0.5		210.6	62.0
	1.0		130.0	66.3
	0	100% soil	-	46.3
	0.5		187.2	62.7
	1.0		133.9	69.7

Soil Zinc availability (extracted by DTPA) at harvest stage of maize was affected signif - icantly by zinc fertilizer application (Table 4).The concentration of Zn increase from 0.42 mg Zn Kg $^{-1}$ soil to 2.06 mg Zn kg $^{-1}$ due to Zn application with an increment of 391%. Rates of boron application decreased Zn availability from 1.63 mg Zn kg $^{-1}$ to 1.20 and 0.92 mg Zn kg $^{-1}$ for 0.5 and 1.0 kg B ha^{-1} respe -ctively. Methods of boron application did not have any significant effect. The increase of available Zn in soil with zinc fertilizer application is expected especially with the application of the best source for Zn to a calcareous soil (9,13 14,16). The level of available Zn in soil after harvest (residual Zn) can be considered as low to moderate according to Bashoor et al, (14) .This mean that soil fertilized with Zn-DTPA can be considered as soil with fairly adequate in Zn for next crop.Soil B availability (extracted by hot water) at harvest stage of maize was affected significantly by boric acid fertilizer application (Table5).The concen - tration of B increase from 1.31 mg B kg $^{-1}$ soil to 2.28 and 2.63 mg B kg $^{-1}$ due to 0.5 and 1.0 kg B ha-1 respectively with an increment of 74 and 100% compared to control. Rates of Zn applied increased B availability from 1.8 mg B Kg^{-1} to 2.4with an increment of 33%. The increase of available B in soil with B fertilizer application is expected especially with the application of one of the best source for B (boric acid) (16,17). The level of available B in soil after harvest (residual B) can be considered as moderate to high according to Peverill, (22) and Bashoor et al, (11).. Peverill, (21)indicated that 0.32–0.38 mg B kg^{-1} soil can be considered as critical Range .This mean that soil fertilized with Boric acid can be considered as soil with fairly adequate in B for next crop especially with nutrient such boron .

Table 4. soil Zn availability at harvest.

Levels of Zn applied (kg ha^{-1})	Levels of B applied (kg ha^{-1})	Method of B application	DTPA extractable Zn Mg Zn kg^{-1} soil
0	0	90% soil+10% foliar	0.68
	0.5		0.30
	1.0		0.27
	0	100% soil	0.64
	0.5		0.39
	1.0		0.26
10	0	90% soil+10% foliar	2.86
	0.5		2.06
	1.0		1.82
	0	100% soil	2.32
	0.5		2.03
	1.0		1.34
LSD 0.05			0.76

Table 5. Effects of Zn and B application on hot water.extractable.

Levels of Zn applied (kg ha^{-1})	Levels of B applied (kg ha^{-1})	Method of B application	Hot water extractable B mg B kg^{-1} soil
0	0	90% soil+10% foliar	1.68
	0.5		1.92
	1.0		2.57
	0	100% soil	0.81
	0.5		1.75
	1.0		2.07
10	0	90% soil+10% foliar	1.53
	0.5		3.02
	1.0		3.11
	0	100% soil	1.23
	0.5		2.43
	1.0		2.75
LSD 0.05			0.13

REFERENCES

1.Abat, Margaret Abat, F. Degryse , R. Baird and M. J. McL aughlin .2015. Responses of Canola to the Application of Slow-Release Boron Fertilizers and Their Residual Effect. Soil Sci. Soc. Am. J. 79:97–103.

2.Al-Ameri, B.H.A. , N .S .Ali and A.H. Afaj. 2013. Effect of Zinc and Boron Application on Growth and Corn Yield. Iraqi J. of Sci. and Tech.,4(2):60-74.

3.Al-Ameri, B.H.A., N .S .Ali and A.H. Afaj. 2014. Sorption of Zn and B on calcareous alluvial soil from the middle of Iraq .Iraqi J. of Science and Technology ,5(1):52-59.

4.Al-Badeary, A.H.T.2001.Effect of Seeds Soa -king, Dusting and Foliar Application of Iron and Zinc Sulfate on Corn Yield. M.Sc.Thesis .College of Agriculture, University of Baghdad.

5.AL-Essawy ,Y.J.A. 2010. Effect of Foliar Application with Boron and Zinc Elements on Growth and Yield of 6 Varieties of Faba Bean (*Vicia faba* L.).PhD. Dissertation .College of Agriculture, University of Baghdad.

6.Al-Hadethi,A.A.;G.Alqwaz,;andR.S.Abbas. 2008.Effect of zinc fertilization on yield comp -onent of two wheat cultivars. Al-Anbar J.of Agric. Sci.6(1):20-28.

7.Al-Hadethi, A.A.2009 The efficiency of zinc humate as a zinc source in calcareous soils.. 4th Conference on Recent Technologies in Agri - culture, 2009.

8.Ali .N.S. 2012.Fertilizer Technology and Uses University of Baghdad .

9.Ali, N. S.; J.K. Al-uqali and B.H. Al-Ameri .2002. "Solubility and precipitation of some zinc fertilizer in calcareous soils"_Basra Jou - rnal of Agricultural Sciences 15(2):-127-138. 2002.

10. Ali,N.S.J.K .Al-uqali and B.H.Al-Ameri 2001.Efficiency of some zinc fertilizer in som e calcareous soils. Iraqi J. of Agric. Scien- ces .32:197-206.

11. Aref, F. 2011. Zinc and boron content by maize leaves from soil and foliar application of zinc sulfate and boric acid in zinc and boron deficient soils. Middle East J. Sci. Res. 7(4): 610−618.

12.Ati , A.S. and N.S. Ali . 2012. The Effect of boron fertilization on faba bean (*Vicia faba* L) yield, fertilizer and water productivity. Euphrates J .of Agric. 81-86.

13.Barker, A. V., and D. J. Pilbeam. 2007 and -book of Plant Nutrition. CRC Press, Taylor and Francis, USA.

14.Bashoor, E,A. Alsaagh ,D. Anak ,H. Abua -lhaq, N.B. Doblis, and N. Ahmed .2007. FAO

Manual for Fertilizer Uses in Far East .2007.FAO, Rome.
15.Goldberg, S. 1997. Reactions of boron with soils. Plant Soil, 193: 1−2.
16.Gupta, U.C.2007.Boron .In Barker, A. V., and D. J. Pilbeam. 2007. Handbook of Plant Nutrition. CRC Press, Taylor and Francis, USA.
17.Havlin, J.L. , Beaton, J.D., Tisdal, S.L. and Nelson,W.L.2005.Soil Fertility and Fertilizers 18. An Introduction to Nutrient Management. New Jersey.18.Hussein, M.A.2011.Effect of spraying some nutrients on growth, floral biology an early and total yield of *Vicia faba* L. M.Sc. Thesis .College of Agriculture, University of Baghdad.
19. Lindsay, W.L. 1991. Inorganic equilibria affecting micronutrients in soil.n Micronutri - ents in Agriculture. 2nd edition. J.J. Mortvedt, F.R. Cox L.M. Shuman and R.M. Welch. pp. 89-112. Soil Soc. Amer. Book Series No. 4. Madison, Wisconsin, USA.
20.Lindsay,W.L.and W.A.Norvell.1978. Devel -opment of a DTPA soil test for zinc, iron, manganese and copper. Soil Sci .Soc .Am. J.42:421-428.
21.Page, A.L.; R.H. Miller, and D.R. Keeney 1982 Soil Analysis. Part 2 Chemical and Micr-obiological Properties.ASA,SSSA Madison, Wisconsin, USA.
22.Peverill, K.I. (Ed).2001 .Soil analysis. A Interpretation Manual .CSIRO, Australia.
23.Rashid, A., M. Yasin, M. Ashraf , and R.A. Mann,R.A.2004.Boron Deficiency in Calcar - eous Soils Reduces Rice Yield and Impairs Grain Quality .International Rice Research Notes.29:58-60
24.SAS Institute. 2001. SAS User's Guide , Release Version 8. 2. SAS Inst., Cary, NC.
25.Sillanpaa, M. 1982. Micronutrients and the Nutrient Status of Soils: A Global Study, FAO Soils Bulletin No. 48, FAO, Rome.
26.Sillanpaa, M. 1990. Micronutrient Assessm -ent at Country Level: An International Study .FAO Soils Bulletin No. 63, FAO, Rome.
27.Soil survey staff (SSS).1975.Soil Taxonmy :A Basic System of Soil Classifi -cation for Making and Interpreting Soil Surveys. Soil Conservation Services, USDA, Washington D.C., Agric. Hand book .436.
28.Tariq, M., and C. J. B. Mott. 2007. Effect of boron on the behavior of nutrients in soil-plant systems-a review. Asian J. Plant Sci. 6: 195−202.
29.Vitosh,M. L.,D.D.Warneke , and R.E.Lucas 1997.Boron. Michigan State University Exte - nsion Soil and Management Fertilizer. Avail - able on the htpp://www.Msue.msu.EDV.
30.Ziaeyan, A.H. and M. Rajaie .2009.Comb - ined effect of Zn and B on yield and nutrient accumulation in corn. International J. of Plant Production.3(3):35-44.