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RESPONSE OF WHEAT TO DIFFERENT DOSES OF $ZnSO_4$ UNDER THAL DESERT ENVIRONMENT

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Abstract

Effect of Zn as Zinc sulphate on wheat crop cultivar 'AS-2002' was investigated through field experiments laid out at Adaptive Research Farm and Farmer's fields under arid environment of Thal desert at Karor district Layyah during Rabi 2005-06 and 2006-07. Levels of $ZnSO_4$ (33%) applied were 0, 7.5, 15, 22.5 and 30 kg ha^{-1}. As evidenced by the grain yield successive increase in grain yield was witnessed with each incremental dose of Zn reaching the threshold level of $ZnSO_4$ at 22.5 kg ha^{-1}. But, for the economic gains in terms of each Rupee invested in Zinc, 7.5 kg $ZnSO_4$ coupled with recommended dose of NPK generated the maximum return (1:4.08) based on the mean performance at both locations and averaged over the two year studies. The Zn application at 22.5 kg ha^{-1} having the mean CBR of 2.93 emerged as the next remunerative treatment in the studies. Thus, in the light of our findings it is recommended that alongwith the recommended dose of NPK at 114-84-62 kg NPK ha^{-1}, $ZnSO_4$ 33% may be applied with the first irrigation either at 7.5 or 22.5 kg ha^{-1} for the highest economic returns in wheat production under the agro-ecological conditions of Thal desert. Further studies are suggested to elaborate the present findings.

Introduction

Soils of Pakistan are generally alkaline in reaction and calcareous in nature. These types of soils usually contain low amount of available micronutrients, particularly Zinc deficiency is widespread in cereals that are grown on calcareous soil (Maqsood *et al*., 2009; Rashid & Ryan, 2008). The main soil factors affecting the availability of Zn to plants are low in total Zn contents, high pH, high calcite and organic matter contents and high concentrations of Na, Ca, Mg, bicarbonate and phosphate in the soil solution or in labile forms. Maize is the most susceptible cereal crop, but wheat grown on calcareous soils and lowland rice on flooded soils are also highly prone to Zn deficiency. Zinc fertilizers are used in the prevention of Zn deficiency and in the biofortification of cereal grains (Alloway, 2009). Another study shows that Zinc efficiency traits for sandy and clayey soils appear to be genetically different. Zinc-efficient genotypes absorb more zinc from deficient soils, produce more dry matter and more grain yield (Graham *et al*., 1992). Zinc deficiency in Pakistan soils has been recognized (Hadi *et al*., 1997). Khattak & Parveen (1986) also reported the Zn deficiency in NWFP. Studies of Marwat *et al.,* (2007) reveled the merit of Zn application to maize crop. Recent studies of Abbas *et al.,* (2007) further show that zinc ranged between deficiency (<0.5 mg kg^{-1}) and adequate limits (>1.0 mg kg^{-1}) in soils of district Sheikhupura, Pakistan. Pervaiz *et al*., (2003) found Zn @ 7.5 kg ha^{-1} as the optimum dose in rainfed wheat in the district Jehlum. The highest increase (109%) in wheat grain yield was obtained with the soil application and the lowest increase (40%) with the leaf application (Yilmaz *et al.*, 1997).The inferences of Harris *et al*., (2004) exhibit 15% increase in wheat grain yield with the application of

$ZnSO_4$. Further findings of Harris *et al*., (2007) and Harris *et al*., (2008) recommend seed priming of maize, wheat chickpea with $ZnSO_4$ for the highest economic returns. However, findings of Sial *et al*., (2005) and Irshad *et al*., (2004) manifest a differential response of varying genotypes of American upland cotton, whereas, Hacisalihoglu *et al*., (2003) attribute the tolerance of wheat genotypes to Zn deficiency due to the level of Zn-requiring enzymes.

Field studies showed an increase in the dry matter and grain yield in wheat in NWFP due to the micronutrients including Zn (Asad & Rafique, 2002). Similarly, Khan *et al.*, (2005) conducted investigations to evaluate the micro-mineral status of pastures having high population of small ruminants in Punjab, Pakistan.

Wheat (*Triticum aestivum* L. em. Thell.) is the principal staple food crop of Pakistan. The fast growing population of the country makes it imperative to achieve matching increases in the rate of food production. Since new areas, which can be brought under cultivation, are limited, high yield per unit area, therefore, has to be achieved to meet food requirements of the country. Nutrient deficiency in our soils and crops is a limiting factor for crop production, because nutrient removals are far more than the nutrient addition. This situation has rendered most of the soils deficient in essential plant nutrients. Consequently the present fertility status of soils cannot sustain high yield.

Zinc is essential for the normal healthy growth and reproduction of plants and plays a key role as a structural constituent or regulatory co-factor of a wide range of enzymes in many important biochemical pathways (Kabata-Pendias & Pendias, 2001). Sharma *et al*., (1987) showed that anthers from the Zn deficient maize plants revealed accelerated activity of peroxidase, ribonuclease and phosphatase. Subsequently Sekimoto *et al*., (1997) elucidated that Zinc deficiency in *Zea mays* L., markedly reduced the level of GA_1. The level of IAA was also decreased although not as markedly. Castasterone was affected less than IAA by zinc deficiency

The Thal desert, situated in Punjab, Pakistan is a vast area mainly between Jhelum and Indus Rivers in neighbourhood of Pothohar Plateau. Its total length from north to south is 190 miles, and its maximum breadth is 70 miles while minimum breadth is 20 miles. This region is divided into the districts Bhakkar, Khushab, Mianwali, Jhang, Layyah and Muzzafargarh. Karor district Layyah lies between 30^o 24’ North latitude and 70^o 44’ to 71°-50', East longitude. The physicochemical properties of soil (0-15cm) of A.R.Farm Karor District Layyah include the soil texture as loamy having: sand 40.70%, silt 37.30% and clay 22%. There is pH 8.1, Organic matter 0.85%, $CaCO_3$ 5.5%, EC 1.5 dSm^{-1}, available N 0.60 g kg^{-1}, available P 10.5 mg kg^{-1}, exchangeable K 125 mg kg^{-1} and AB-DTPA extractable Zn 0.93 mg kg^{-1}, AB-DTPA extractable Fe 2.95 mg kg^{-1} and AB-DTPA extractable Mn 1.15 mg kg^{-1} (Personal Communication).

Limited information is available regarding zinc requirement of wheat crop in sandy soils of the arid environment of Thal desert. Therefore, the present studies were undertaken to contemplate the optimum dose of zinc under the arid environment for obtaining sustainable wheat yield.

Materials and Methods

The experiments were conducted at Adaptive Research Farm Karor and Farmer’s field located at Chak No. 116 TDA, Tehsil Karor, Distt. Layyah (Thal desert) during Rabi (winter) 2005-06 at Adaptive Research Farm Karor and Farmer’s field located at Chak No. 138 TDA, Tehsil and Distt. Layyah during Rabi, 2006-07. The experiments were comprised of seven treatments laid out in triplicated RCBD.

The detail of treatments is as under:

T_1 = control (no fertilizer)

T_2 = 114-57-0 NPK kg ha^{-1} (Farmer's practice)

T_3 = 114-84-62 NPK kg ha^{-1} (Agriculture Department's Recommendation)

T_4 = 7.5 kg 33 % $ZnSO_4$ + Agriculture Department's Recommendation of NPK

T_5 = 15 kg 33 % $ZnSO_4$ + Agriculture Department's Recommendation of NPK

T_6 = 22.5 kg 33 % $ZnSO_4$ + Agriculture Department's Recommendation of NPK

T_7 = 30 kg 33 % $ZnSO_4$ + Agriculture Department's Recommendation of NPK

The experiments were irrigated at the required frequency of irrigations at each location. Phosphorus and Potassium were applied as a basal dose and nitrogen as per recommendation after sowing while $ZnSO_4$ doses were applied 20 days after sowing with irrigation. The wheat variety 'AS-2002' was used as a test crop. The yield data were recorded by harvesting randomly selected 3 x 3 m^2 area from each treatment and were statistically analyzed by using analysis of variance technique and the differences among treatment means were compared by using least significant difference test (Steel & Torrie, 1980). The economic analyses data were performed separately for either of the locations studied.

Results and Discussion

The data on grain yield were subjected to statistical analysis and significant differences were depicted among treatments. Differences among the treatment means were detected by using least significance test (Table 1). Even though yield per hectare was different at A. R. Farm and Farmer's field during Rabi 2005-06 and 2006-07. But the trend of results due to different treatments was similar each year at both locations (Table 1). The perusal of data at A.R. Farm during 2005-6 reveals that the highest grain yield (4077 kg ha^{-1}-was recorded in 22.5 kg $ZnSO_4$ ha^{-1} in addition to the departmental recommendation of NPK registering an increase of 164, 13 and 8% over the untreated control, farmer's practice and the departmental recommendation, respectively. The $ZnSO_4$ at 15 kg ha^{-1} coupled with the departmental recommended level of NPK ranked the second top scoring treatment as far as the grain yield is concerned (Table 1).During the same year of studies at the Farmer's field the top scoring treatments viz., 22.5 and 15 kg ha^{-1} Zn coupled with the departmental recommendation of the NPK yielded statistically similarly, but outyielded the rest of the treatments included in the studies (Table 1). It is evident from the data that on Farmer's field the yield gap between the different treatments and the untreated check was narrower as compared to the Adaptive Farm Trial during the year under reference. An increase to the magnitude of 98, 13, and 12%, over the untreated control, farmer's practice and the departmental recommendation, respectively was recorded in top ranking 22.5 kg Zn ha^{-1}. The locations mean during 2005-6 shows an increase of 99 (Departmental recommendation alone to 129% (22.5 kg Zn ha^{-1} (Table 1). The data during 2005-6 further reveals that $ZnSO_4$ emerged as the threshold level and further increase in the dose proves detrimental to the crop (Table 1).

During the succeeding year of studies a similar trend in the performance of different treatments was deciphered. The top ranking 22.5 kg Zn ha^{-1} stayed statistically significant top ranking at either of the locations. Likewise, it also appeared to be the threshold level as far the grain yield is concerned (Table 1). These findings are in a great analogy with the previous work of Hadi *et al.,* (1997), Jain & Dhama (2007) and Ranjbar & Bahmaniar (2007), who harvested increased yield with the application of Zn.

Table 1. Effect of different doses of $ZnSO_4$ with recommended NPK on grain yield (kg ha^{-1}) of wheat.

Treatments		2005-6			2006-7		
		A.R. Farm	Farmer's field	% Increase over farmer's practice	A.R. Farm	Farmer's field	% Increase over farmer's practice
T_1	Control (no fertilizer)	1547 e[1]	1825 e		1813 g	1291 g	
T_2	Farmer's practice†	3611 d	3179 d	-	3538 f	2759 f	-
T_3	Department's Recommendation‡	3767 c	3224 c	3.09	3555 e	2791 e	0.76
T_4	7.5 kg 33% $ZnSO_4$+ Department's Recommendation	3804 c	3470 b	7.13	3960 c	3030 d	10.99
T_5	15 kg 33% $ZnSO_4$+ Department's Recommendation	3890 b	3590 a	10.16	4020 b	3149 b	13.85
T_6	22.5 kg 33% $ZnSO_4$+ Department's Recommendation	4077 a	3606 a	13.17	4350 a	3188 a	19.69
T_7	30 kg 33% $ZnSO_4$+ Department's Recommendation	3787 c	3478 b	7.01	3920 d	3059 c	10.83
	$LSD_{0.05}$	38.50	25.19		14.82	5.538	

†Farmer's practice = 114-57-0 NPK kg ha^{-1}

‡Department's Recommendation = 114-84-62 NPK kg ha^{-1}

[1]The means sharing a letter in common in the respective column do not differ significantly by the LSD test $p \leq 0.05$.

Table 2. Economic analysis the effect of different doses of $ZnSO_4$ on the yield of wheat at Adaptive Research Farm (Pooled data of 2005-06 & 2006-07).

Treatment	Mean yield (kg ha $^{-1}$)	Added yield (kg ha $^{-1}$)	% Increase over farmer's practice	Total exp. (Rs.)	Total income (Rs.)	Net income (Rs.)	Added expenditure (Rs.)	Added income (Rs.)	CBR
T_1	1680	-	-	-	20378	-	-	-	-
T_2	3574	-	-	9000	43358	34358	-	-	-
T_3	3661	87	2.43	11100	44407	33307	-	-	-
T_4	3882	308	8.63	11975	47088	35113	875	3736	1:4.26
T_5	3955	381	10.66	12850	47974	35124	1750	4615	1:2.63
T_6	4214	639	17.88	13725	51115	37390	2625	7751	1:2.95
T_7	3853	279	7.80	14600	46736	32136	3500	3384	1:0.96

Table 3. Economic analysis the effect of different doses of $ZnSO_4$ on the yield of wheat at farmer's field (Pooled data of 2005-06 & 2006-07).

Treatment	Mean yield (kg ha $^{-1}$)	Added yield (kg ha $^{-1}$)	% Increase over farmer's practice	Total exp. (Rs.)	Total income (Rs.)	Net income (Rs.)	Added expenditure (Rs.)	Added income (Rs.)	CBR
T_1	1558	-	-	-	18898	-	-	-	-
T_2	2969	-	-	9000	36014	27014	-	-	-
T_3	3008	39	1.31	11100	36487	25387	-	-	-
T_4	3250	281	9.46	11975	39422	27447	874	3408	1:3.89
T_5	3369	400	13.47	12850	40865	28015	1750	4852	1:2.77
T_6	3597	628	21.15	13725	43631	29906	2625	7618	1:2.90
T_7	3268	299	10.07	14600	39641	25041	3500	3627	1:1.03

A reference to Table 2 exhibits the economic implications of different treatments at the Adaptive Research Farm. The Cost Benefit Ratio (CBR) is computed in the last column. The added income amounting to Rs.7751 in T6 is the highest among all the treatments, but based on the cost of treatments, the highest mean cost benefit ratio (1:4.26) was recorded in T4 (7.5 kg $ZnSO_4$ + department's recommendation. Income-wise most remunerative treatment was T6 (22.5 kg $ZnSO_4$ + department's recommended failed to have the outstanding CBR due to higher investment in the cost of Zinc. However, with a CBR of 2.95, it ranked as the second top scoring in the array of treatments (Table 2).

At farmer's field, similar trend in the economics of different treatments was registered (Table 3). The Treatments T4 and T6 remained on the top as at Adaptive Farm experiments. However, the economic gain was slightly lesser at the Farmer's field as compared to the Adaptive Farm for each Rupee invested in the cost of different treatments.

Similar findings were communicated by Harris *et al*., (2004; 2007; 2008) who obtained a boost in crop yields due to seed priming with Zn or direct application to the crop. The increase in the grain yield leading to the higher economic return is attributable to the improved physiology of plants with the added Zn consequently correcting the efficiency of different enzymes leading to higher yield (Sharma *et al*., 1987; Kabata-Pendias & Pendias, 2001; Sekimoto *et al*., 1997; Hacisalihoglu *et al*., 2003)).

Further studies are suggested to explore the tolerance of different cultivars of wheat to Zn deficiency and extend recommendations accordingly (Irshad *et al*., 2004; Sial *et al*., 2005; Maqsood *et al*., 2009).

Conclusions

Conclusions could be drawn from two-year studies at A.R. Farm Karor and Farmer's field that optimum level of $ZnSO_4$ 33% is 22.5 kg ha^{-1} applied in addition to the departmental recommendation of the NPK, for harvesting maximum yield per unit area. But, for the economic gains on each Rupee spent in Zinc 7.5 kg $ZnSO_4$ coupled with recommended dose of NPK generates the maximum return (1:4.08) based on the mean performance at both locations and averaged over the two year studies. The application of Zinc is recommendation with first irrigation.

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