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Wheat response to Zn and K application under rainfed conditions

R. Hussain[1*], M. Rashid[2], M. Akram[1], K. Hussain[3] and A. R. Jami[1]
[1]Soil & Water Conservation Research Institute, Chakwal
[2]Ayub Agricultural Research Institute, Faisalabad
[3]Soil & Water Conservation Research Station, Sohawa

Abstract

The study was carried out for three years (2002-2003 to 2004-2005) to evaluate the wheat response to Zn and K application under rainfed conditions. The four field experiments were conducted every year at farmer's fields in each district of Chakwal, Attock and Jhelum. Zinc was applied @ 4 & 8 kg Zn ha^{-1} as zinc sulphate and K @ 50 & 100 kg K_2O ha^{-1} as MOP along with 120 kg N ha^{-1} as urea and 80 kg P_2O_5 ha^{-1} as DAP as basal dose at the time of sowing. A control (NP only) was also kept for comparison. Wheat variety Inqulab-91 was sown at all the 36 sites in last week of October every year. Average of three years results revealed a positive and significant response of wheat to Zn and K application. Application of zinc @ 4 kg Zn ha^{-1} enhanced the wheat grain yield (3022 kg ha^{-1}) about 13% over control (2671 kg ha^{-1}). While potassium @ 50 kg K_2O ha^{-1} increased the wheat grain yield (2997 kg ha^{-1}) about 12% over control. Further improvement in yield due to higher rates of Zn and K_2O i.e. 8 and 100 kg ha^{-1}, respectively was not observed. Effect of soil texture on wheat yield was not prominent as initial soil test ranges of Zn and K levels were in close proximity. Application of Zn and K holds promise for improved wheat yield when applied on soils requiring supplementation.

Key words: Wheat, rainfed, zinc, potassium, grain yield

Introduction

The wheat (*Triticum aestivum*) is an important Rabi crop in rainfed tract of the Punjab. To get optimum yield, a balance dose of macro as well as micronutrients is required. Zinc is one of the nine essential micronutrients needed for growth and development of wheat (Brady and Weil, 1996). The Pakistan soils are conducive to micronutrients deficiency due to their calcareous alkaline nature and low soil organic matter content. In rainfed area, the zinc deficiency is widespread. Rashid and Rafique (1996) conducted a survey and demonstrated that 66% soils of surveyed area of rainfed zone were found deficient in Zn content. Hadi *et al.* (1997) reported 48 percent increase in wheat grain yield with 22.6 benefit cost ratio with 10 kg Zn SO_4 ha^{-1}. Sharma *et al.* (2000) reported that wheat responded only to 5 kg Zn ha^{-1} and Zn at this rate resulted in 13.62 and 6.14% higher grain yield compared to the control and 10 kg Zn ha^{-1}, respectively. Kausar *et al.* (2001) conducted a pot culture study and reported the maximum grain yield of wheat variety Inqulab-91 and Pasban with soil applied Zn @ 4 and 2 mg kg^{-1}, respectively. Rehman *et al.* (2001) reported that 5 kg Zn ha^{-1} appeared to be the optimum dose for conditioning wheat yield under experimental condition. The agronomic efficiency (GNR) reduced with subsequent increase in Zn application level. Iqbal *et al.* (2002) reported that in barani zone of Punjab, the wheat yield increased significantly at 5 kg Zn ha^{-1} over control. The VCR of 4:1 and GNR of 76:1 were also obtained against 5 kg Zn ha^{-1}. Asad and Rafique (2002) reported that application of Zn @ 4 kg ha^{-1} in soil classified as Udic Haplustaf, increased grain and straw yields of wheat significantly over control. They further indicated that soil test for Zn was increased both at booting and harvesting stage. Qiang (2004) reported that $ZnSO_4.7H_2O$ fertilizers increased the leaf area of wheat, promoted tillering ability and accumulation of dry matter compared to control. He also concluded the optimum zinc sulfate fertilizer rate for wheat as 30-45 kg ha^{-1}. Jana *et al.* (2005) reported that application of zinc sulfate @ 30 kg ha^{-1} to wheat grown in red and laterite soils; increased plant height by 3.2%, effective tillers by 11.6%, panicle length by 3.8% and grains per panicle by 11% over control.

Potassium (K^+) is an essential plant nutrient taken up from soil in large quantity. Soil solution and exchangeable-K are in equilibrium and, collectively, known as the readily available K pool (bio-available). The bioavailable K pool is only a minor fraction of the total soil K reserve (Huang, 2005). Potassium is a third major element in plant nutrition and is vital for many important metabolic functions and high yields. It is absorbed by wheat and other crops in larger amount than any other mineral element except N (Kemmler, 1983). Several soil factors are held responsible in determining the crop responses to applied K, and soil test K that is based on a single extraction of adsorbed K, often fails to predict the outcome of a fertilizer addition. Clayey soils generally contain more plant available K than loamy and sandy loam soils (Bajwa and Rehman, 1994). Siddique *et al.* (1997) reported that potassium application @ 100 mg K_2O kg^{-1} soil produced highest number of tillers $plant^{-1}$, plant height and straw yield whereas highest grain yield of wheat

*E-mail: sawcri@gmail.com

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height and straw yield whereas highest grain yield of wheat was recorded with 75 mg K_2O kg^{-1} of soil. Ahmad *et al.* (2001) reported that potassium application @ 75 kg K_2O ha^{-1} caused significant increase in grain yield of wheat compared to check while further addition of K failed to enhance yield. They also observed the significant effect of K on loam and silty clay loam soils and it was non significant in sandy loam and silt loam soils. Nadeem and Ibrahim (2001) reported that potassium application @ 75 and 150 kg K_2O ha^{-1} gave significantly higher and economical grain yield of wheat over control. They further observed that wheat crop responded to potassium application in clay loam soil but not in loam soil. Keeping these in view, the field trials were conducted to evaluate wheat response to Zn and K application under rainfed conditions.

Materials and Methods

The four field experiments in single replication were conducted every year at farmer's fields in each district of Chakwal, Attock and Jhelum during 2002-2003 to 2004-2005 to study the wheat response to Zn and K application under rainfed conditions. The soil samples from 0-15 and 15-30 cm depths were collected before sowing of wheat each year and analyzed for fertility status (Table 1, 2 &3). The P was determined after extraction with 0.5 M $NaHCO_3$ (Olsen *et al.*, 1954) and K by using 1 M CH_3COO NH_4 (Pratt, 1965). Zinc contents were determined by extraction with DTPA (Lindsay and Norvell, 1978) by using Atomic Absorption Spectrophotometer technique.

All NPK and Zn fertilizers were applied by broadcast at the time of wheat sowing. The experiment was laid out by employing randomized complete block design (RCBD). Zinc was applied @ 4 & 8 kg Zn ha^{-1} as zinc sulphate and K @ 50 & 100 kg K_2O ha^{-1} as MOP along with 120 kg N ha^{-1} as urea and 80 kg P_2O_5 ha^{-1} as DAP as basal dose. A control (NP only) was also kept for comparison. The wheat variety Inqulab-91 was sown at all 36 sites in last week of October every year. The wheat grain yield data of three years were recorded and analyzed statistically by using analysis of variance techniques and LSD compared differences among treatment means at $p < 0.05$ (Gomez and Gomez, 1984). The rainfall distribution was highly variable in each district every year, which is presented in (Figure 1).

Results and Discussion

The grain yield results (Table 4, 5 & 6) revealed a

Table 1. Soil analysis before sowing of wheat at Chakwal

Parameters	Depths (cm)	2002-2003	2003-2004	2004-2005	Mean
Organic matter	0-15	0.52	0.58	0.45	0.52
(%)	15-30	0.42	0.63	0.35	0.47
Available-P	0-15	7.1	6.6	6.2	6.6
(mg kg^{-1})	15-30	5.3	5.5	3.5	4.8
Available-K	0-15	176	138	132	149
(mg kg^{-1})	15-30	157	139	117	138
Zn	0-15	0.9	1.07	1.42	1.13
(mg kg^{-1})	15-30	1.0	1.19	1.38	1.19
Textural Class		Sandy clay loam	Clay loam	Loam	

Table 2. Soil analysis before sowing of wheat at Attock

Parameters	Depths (cm)	2002-2003	2003-2004	2004-2005	Mean
Organic matter	0-15	0.56	0.48	0.44	0.49
(%)	15-30	0.46	0.32	0.41	0.40
Available-P	0-15	6.3	4.6	4.1	5.0
(mg kg^{-1})	15-30	5.0	3.2	3.9	4.0
Available-K	0-15	119	123	102	115
(mg kg^{-1})	15-30	100	119	93	104
Zn	0-15	1.09	0.98	0.77	0.95
(mg kg^{-1})	15-30	0.85	1.10	0.95	0.97
Textural Class		Sandy loam	Loam	Sandy loam	

Table 3. Soil analysis before sowing of wheat at Jehlum

Parameters	Depths (cm)	2002-2003	2003-2004	2004-2005	Mean
Organic matter (%)	0-15	0.67	0.45	0.39	0.50
	15-30	0.49	0.42	0.27	0.39
Available P (mg kg^{-1})	0-15	7.9	4.1	2.9	4.9
	15-30	5.9	4.1	2.5	4.2
Available K (mg kg^{-1})	0-15	140	161	179	160
	15-30	114	158	167	146
Zn (mg kg^{-1})	0-15	1.61	1.08	1.99	1.56
	15-30	1.78	1.23	1.84	1.62
Textural Class		Silt Loam	Loamy clay	Sandy loam	

Table 4. Effect of Zn and K application on grain yield of wheat at Chakwal

Fertilizer (kg ha^{-1})	Grain yield (kg ha^{-1})			
N - P_2O_5 - K_2O -Zn	2002-2003	2003-2004	2004-2005	Mean
120 - 80 - 0 - 0	2845	2813	2510	2723 b
120 - 80 - 50 - 0	2992	3037	3112	3047 a
120 - 80 - 100 - 0	3281	3129	3150	3187 a
120 - 80 - 0 - 4	3145	2831	3198	3058 a
120 - 80 - 0 - 8	3102	2825	3261	3063 a
Mean	3073 N.S (P<0.05)	2927	3046 N.S	LSD=301.4 (P<0.05)

Table 5. Effect of Zn and K application on grain yield of wheat at Attock

Fertilizer (kg ha^{-1})	Grain yield (kg ha^{-1})			
N - P_2O_5 - K_2O - Zn	2002-2003	2003-2004	2004-2005	Mean
120 - 80 - 0 - 0	2372	1822	3345	2505 b
120 - 80 - 50 - 0	2687	2200	3708	2865 a
120 - 80 - 100 - 0	2395	1967	3718	2693 ab
120 - 80 - 0 - 4	2570	1944	3823	2779 ab
120 - 80 - 0 - 8	2151	1767	3793	2570 b
Mean	2435 b LSD= 221.2	1940 b (P<0.05)	3677 a	LSD= 285.6 (P<0.05)

positive and significant response of wheat to Zn and K application. The grain yield of wheat in all the districts increased significantly at ($p<0.05$) over control.

District Chakwal

In district Chakwal, the grain yield (Table 4) showed that application of zinc @ 8 kg Zn ha^{-1} increased wheat grain yield (3063 kg ha^{-1}) by about 12% over control (2723 kg ha^{-1}), it was statistically at par with 4 kg Zn ha^{-1}. Application of potassium @ 100 kg K_2O ha^{-1} produced wheat grain yield (3187 kg ha^{-1}) about 17% higher over control, it was statistically also at par with 50 kg K_2O ha^{-1}. During all the years, the difference among wheat grain yield was found to be non-significant

District Attock

In district Attock, the grain yield (Table 5) depicted that application of zinc @ 4 kg Zn ha^{-1} increased wheat grain yield (2779 kg ha^{-1}) by about 11% over control (2505 kg ha^{-1}). Application of potassium @ 50 kg K_2O ha^{-1} produced wheat grain yield (2865 kg ha^{-1}) about 14% higher over control. During 2004-2005, the highest grain yield (3677 kg ha^{-1}) was recorded because a highest rainfall of 543 mm was received during growing period of wheat.

District Jehlum

In district Jehlum, the grain yield (Table 6) indicated that application of zinc @ 8 kg Zn ha^{-1} increased wheat grain yield (3361 kg ha^{-1}) by about 21% over control (2776 kg ha^{-1}), which was statistically at par with 4 kg Zn ha^{-1}. Application of potassium @ 50 kg K_2O ha^{-1} produced wheat grain yield (3080 kg ha^{-1}) about 11% higher over control. During 2003-2004, the highest grain yield (4301 kg ha^{-1}) was recorded compared to other years.

Average wheat grain yield

In rainfed area wheat grain yield affected due to great variation in rainfall.
Generally, 70% rainfall is received in summer monsoon and only 30% in winter.

The average wheat grain yield data (Table 7) of three years recorded from 36 sites revealed a positive and significant response of wheat to Zn and K application. The grain yield of wheat increased significantly over control by all the treatments of zinc and potassium. Application of zinc @ 4 kg Zn ha^{-1} increased wheat grain yield (3022 kg ha^{-1}) by about 13% over control (2668 kg ha^{-1}), which was statistically at par with 8 kg Zn ha^{-1}. Application of potassium @ 50 kg K_2O ha^{-1} produced wheat grain yield (2997 kg ha^{-1}) about 12% higher over control, also which was statistically at par with 100 kg K_2O ha^{-1}. On an average, the further improvement in grain yield due to higher rates of Zn and K_2O i.e. 8 and 100 kg ha^{-1}, respectively, was not impressive. The results of experiments conducted at different sites revealed an area specific response to zinc and potassium application. The order of response in terms of wheat productivity to Zn application was district Jhelum < Chakwal < Attock, which is also confirmed by soil analysis of these districts. The response of wheat to potassium was found to be similar in all the districts. The results of wheat response to Zn are supported by Hadi *et al.* (1997), Sharma *et al*. (2000), Kausar *et al*. (2001), Rehman *et al*. (2001), Iqbal *et al*. (2002), Asad and Rafique (2002), Qiang (2004) and Jana *et al.* (2005). The results of wheat response to K are also in conformity with those of Bajwa and Rehman (1994), Siddique *et al*. (1997), Nadeem and Ibrahim (2001) and Ahmad *et al*. (2001).

Conclusions

The results of present study revealed a significant improvement in grain yield of wheat. Optimum rate of Zinc @ 4 kg Zn ha^{-1} and potassium @ 50 kg K_2O ha^{-1} increased

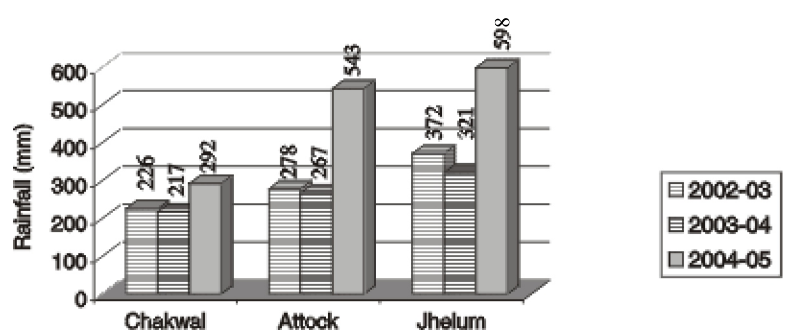
Table 6. Effect of Zn and K application on grain yield of wheat at Jehlum

Fertilizer (kg ha^{-1})	Grain yield (kg ha^{-1})			
N - P_2O_5 - K_2O - Zn	2002-2003	2003-2004	2004-2005	Mean
120 - 80 - 0 - 0	2153	3810	2366	2776 c
120 - 80 - 50 - 0	2203	4535	2503	3080 b
120 - 80 - 100 - 0	2240	4195	2625	3020 bc
120 - 80 - 0 - 4	2390	4405	2896	3230 ab
120 - 80 - 0 - 8	2498	4560	3025	3361 a
Mean	2297 c	4301 a	2683 b	LSD=279.3
	LSD= 216.4	(P<0.05)		(P<0.05)

Table 7. Effect of Zn and K application on average grain yield of wheat

Fertilizer (kg ha^{-1})	Grain yield (kg ha^{-1})			
N - P_2O_5 - K_2O -Zn	Chakwal	Attock	Jehlum	Mean
120 - 80 - 0 - 0	2723	2505	2776	2668 b
120 - 80 - 50 - 0	3047	2865	3080	2997 a
120 - 80 - 100 - 0	3187	2693	3020	2967 a
120 - 80 - 0 - 4	3058	2779	3230	3022 a
120 - 80 - 0 - 8	3063	2570	3361	2998 a
Mean	3016 a	2682 b	3093 a	LSD= 250.7
	LSD= 194.2	(P<0.05)		(P<0.05)

Figure 1. Rainfall (mm) recorded during the growing period of wheat (October to April)



the wheat grain yield at ($p< 0.05$) over control. On the overall basis, there was a little effect on wheat grain yield with application of Zn @ 8 kg ha^{-1} and K_2O @ 100 kg ha^{-1}. From this study, it might be concluded that Zn and K fertilization significantly increased the wheat grain yield over control in rainfed area.

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