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THE YIELD RESPONSE OF WHEAT TO ZINC FERTILIZATION

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ABSTRACT

The experiment on wheat to zinc fertilization was carried out at the Regional Agricultural Research Station, Agricultural Research Sub-Station, and Special Crop Research Stations of BARI and at Farmer's field. The grain yield was increased with increasing application of zinc upto 6 kg/ha but beyond that the level the yield was declined. The highest yield (3.87t/ha) was obtained in 6 kg Zn/ha under Amnura series as compare to Nachole and Lauta series. The lowest yield was obtained in Nachole series (3.07 t Zn/ha) under Deep Grey Terrace Soil. In Gangachara too, the grain yield of wheat was increased with increasing levels of zinc upto 6 kg Zn/ha beyond that it was declined. The highest yield (5.58t/ha) was obtained in 6 kg Zn/ha under Gangachara series and compare to Kaunia and Sonatola series. The lowest yield was obtained (3.92t/ha) in Kaunia series under Grey Floodplain Soils.The grain yield of wheat was significantly increased upto 12 kg Zn/ha in Calcarious Dark Grey Floodplain and Calcarious Brown Floodplain Soils and the order of increase was $Zn_{12}>Zn_9>Zn_6>Zn_3>Zn_0$. The highest yield (5.50 t/ha) was recorded in 12 kg Zn/ha. The order of the yield was Ishardi 5.50 t/ha > Sara5.47 t /ha> Gopalpur 5.13 t /ha>Darsona 2.91t/ha was recorded under Calcarious Dark Grey Floodplain and Calcareous Brown Floodplain Soils.

Keywords: Yield, Wheat, Soil, Zinc and Fertilization

INTRODUCTION

Sommer and Lipman (1926) first proved the essentiality of zinc as a nutrient for higher plants. Zinc is one of the 17 nutrient elements needed in balanced amounts for allowing plants to grow normally. As described by Singh and Mitra (1975) zinc serves as a constituent of metabolic enzyme systems of plants, including alcohol dehydrogenase, carbonic anhydrase and various peptidases. Zinc is involved in biosynthesis of tryptophane, a precursor of auxin, which is essential for cell elongation. High osmotic pressure resulting from Zn deficiency is due to reduced water uptake which is restricted by failure of cell walls to grow because of lack of auxin. Zinc has also been found to be essential for normal chlorophyll formation in plants. Zinc also plays a key role in carbon and protein metabolism in plants. It is also related to seed production in several plants (Singh and Mitra, 1975). There are also contrary reports on Zn-P antagonisms. Chaudhury *et al.* (1977b) observed that P strongly enhanced Zn uptake in flooded rice on a calcareous soil. Ragab (1981) reported that there existed a positive relationship between Zn and P in terms of soil available Zn and plant Zn concentration. Talukder (1982) observed that phosphorous and zinc application increased the grain yield upto 112 kg P_2O_5/ha and 6 kg Zn/ha. The concentration of P and Zn decreased significantly with increasing levles of P and

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Zn. The antagonistic effect of P on Zn was more pronounced than that of Zn on P. With the intensive type of agriculture using HYV's and high analysis fertilizers, reports of deficiency of Zn especially in rice as accentuated by heavy phosphate fertilization are accumulating (Tiwari and Pathak, 1978). The high P supply beyond the optimum rate produced severe Zn deficiency symptoms in cereal crops when Zn was not applied (Takkar *et al.*, 1978). The interaction of Zn and P is usually designated as P-induced Zn deficiency. This disorders in plant growth is the commonly associated with levels of available P and with fresh application of fertilizer P, but it has been observed also with low to medium levels of application. This deleterious effect of P can then easily be corrected by a light application of Zn fertilizer (Singh and Singh, 1980).

MATERIALS AND METHODS

The experiment on Wheat cropping pattern were carried out at the Regional Agricultural Research Station, Agricultural Research Sub-Station, and Special Crop Research Stations of BARI and at Farmer's field. The blanket doses of 120 kg N/ha from urea, 100 kg P_2O_5/ha from TSP 60 kg K_2O/ha from MP, 20 kg S/ha from gypsum along with different levels of Zn (0, 3, 6, 9 and 12) kg/ha from zinc oxide were tested in the experiments. The treatment combinations were T_1(Absolute Control) **,**T_2(N_{120} P_{45} K_{50} S_{20} Zn_0kg/ha)**,**T_3(N_{120} P_{45} K_{50} S_{20} Zn_3kg/ha) ,T_4(N_{120} P_{45} K_{50} S_{20} Zn_6kg/ha) ,T_5(N_{120} P_{45} K_{50} S_{20} Zn_9 kg/ha) and T_6 (N_{120} P_{45} K_{50} S_{20} Zn_{912} kg/ha) . The experiment was laid out in a randomized complete block design with 3 replications and 6 treatments. The unit plot sized was 5m x 4m and row to row distance was 30 cm. The wheat seed (cv. Kanchan) were sown continuous in line. For T.aus, the spacing was maintained as row to row 25 cm and hill to hill 15 cm. The seed rate was 130 kg/ha and 120 kg/ha for wheat and rice respectively. All P, K, S and Zn half on N were applied at the time of the final land preparation and remaining half N was applied before flowering stage for both wheat and rice. The intercultural operations were done as and when necessary for both the crops. The plants were grown to maturity with protection from insects and diseases. The grain sample of wheat and rice were separately processed and dried in the oven at 60^0C for about 24 hours and finally ground in the grinding machine and subsequently stored for chemical analysis. The complete chemical analysis was done following standard method (Hunter, 1984).

RESULTS AND DISCUSSIONS

The results regarding the response of wheat to applied zinc is presented and described below sequentially according to soil series studied.

Response of wheat to zinc

Amnura

The grain yield was increased with the increasing application of zinc up to 6 kg/ha but beyond that level the yield was declined. The highest yield (3.87 t/ha) was obtained in T_3 (6 kg Zn/ha) which was statistically higher over all other treatments except T_2 where 3 kg Zn/ha was applied (Table 1). However, quadratic response curve was fitted on the basis of mean yield as; Y=3.4906 + 0.085X – 0.0095X2 having R^2 = 0.6558. Where, Y = Grain yield (t/ha), X = Levels of Zinc (kg/ha) and R^2 = Regression co-efficient. The optimum dose of Zn was worked out from this equation as 4.47 kg Zn/ha considering the maximum yield 3.87 t/ha (Fig. 1). Thus 4.47 kg Zn/ha might be recommended for yield maximization of wheat in Amnura series under Deep Grey Terrace Soil.

Nachole

The grain yield was increased with the increasing levels of Zn up to 6 kg/ha but declined with further higher rates. The highest yield (3.07 t/ha) in Nachole was found in T_3 (6 kg Zn/ha), which was significantly higher over all other treatments except T_2 (Table 1). However, a quadratic relationship was found between yield and added Zn (Fig. 2). From this quadratic response curve, the optimum dose of zinc was worked out and found to be 5.66 kg/ha considering the maximum yield (3.07 t/ha) of wheat in Nachole series under Deep Grey Terrace Soils.

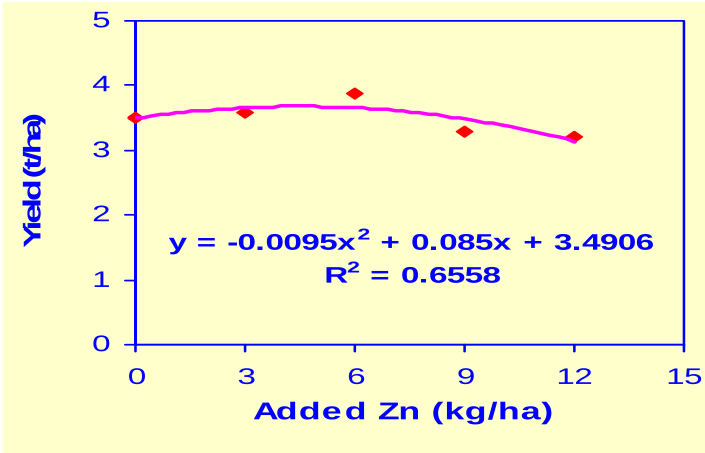

Fig No.1: Response of wheat to added Zn in Amura series

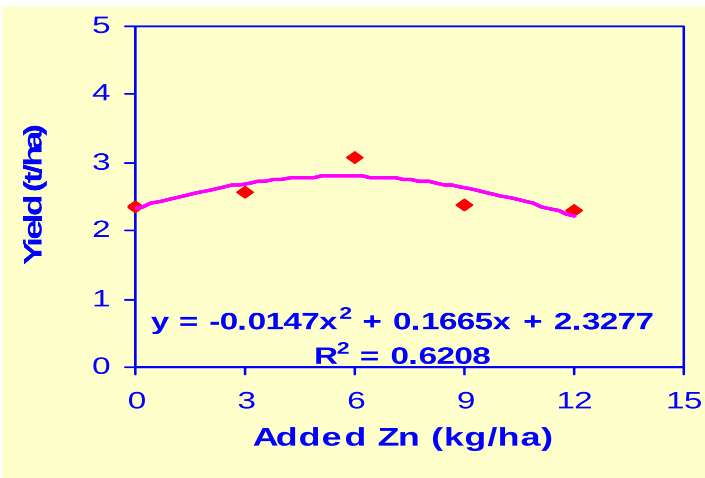

Fig No.2: Response of wheat to added Zn in Nachole series

Lauta

In this series, the grain yield gradually increased up to 6 kg Zn/ha and beyond that level it was declined. The highest yield (3.67 t/ha) was recorded in T_3 followed by T_2 although they are statistically identical but significant over rest of the treatment (Table 1). A quadratic response curve was fitted from the mean yield (Fig. 3). The optimum level of Zn was calculated from the quadratic equation as 5.45 kg Zn/ha considering the maximum yield 3.67 t/ha. Thus, 5.45 kg Zn/ha might be recommended for wheat for yield maximization in Lauta series under Grey Terrace Soil.

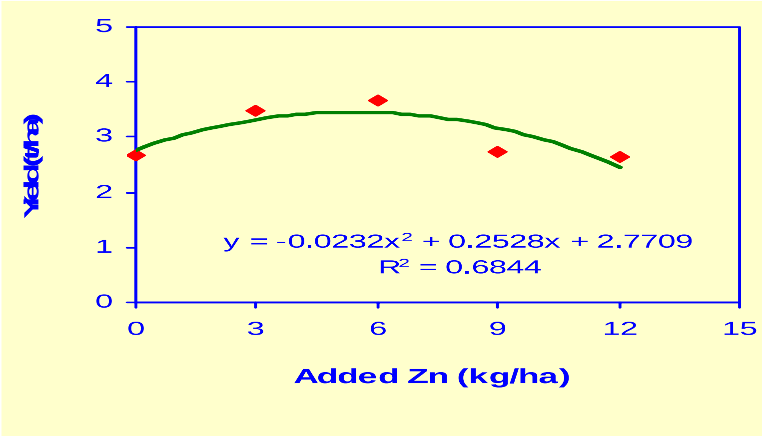

Fig No.3: Response of wheat to added Zn in Lauta series

Gangachara

In Gangachara too, the grain yield of wheat was increased with the increasing levels of zinc up to 6 kg Zn/ha beyond that it was declined. The highest yield (5.58 t/ha) was obtained in T_3 (6 kg Zn/ha), which was significantly higher over rest other treatments. The 2nd highest yield was (4.90 t/ha) obtained with T_2 which was significantly higher over all other treatments except T_3 and T_4 (Table1). A quadratic relationship was found between yield and added Zn (Fig. 4). From the quadratic equation, the optimum dose of zinc was worked out and found to be 5.60 kg Zn/ha considering the maximum yield 5.58 t/ha. Thus, 5.60 kg Zn/ha might be recommended for wheat cultivation for maximizing the yield in Gangachara series under Grey Floodplain Soils.

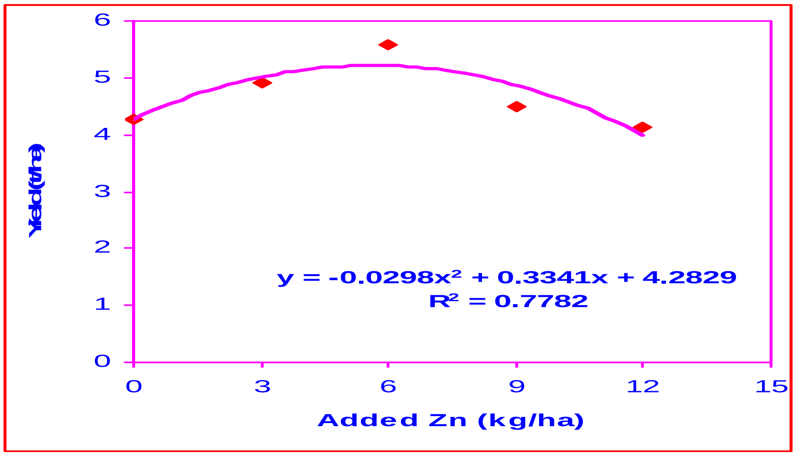

Fig No.4: Response of wheat to added Zn in Gangachara series

Kaunia

The highest yield (3.92 t/ha) was obtained in T_3 which was significantly higher over rest of the treatments (Table1). As the grain yield was progressively increased up to 6 kg Zn/ha and after that it was gradually decreased therefore, a quadratic response curve was fitted on the basis of mean yield (Fig.5). The optimum level of Zn was calculated from the equation as 6.43 kg Zn/ha considering the maximum yield of 3.92 t/ha. As such, 6.43 kg Zn/ha might be suggested for the maximization of wheat yield in Kaunia series under Grey Floodplain Soils.

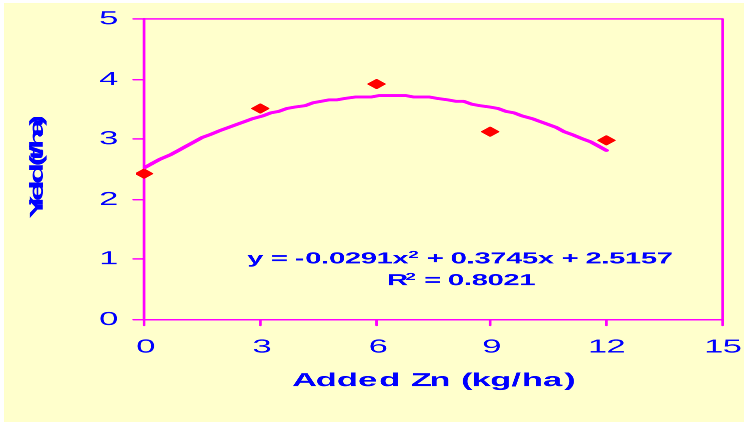

Fig No.5: Response of wheat to added Zn in Kaunia series

Sonatola

Statistically identical grain yield was recorded from T_3, T_2 and T_4 even though the highest yield (3.73 t/ha) was recorded from T_3 (Table1). These results implies that higher but identical yield can be obtained by the application of either 3 kg, 6 kg or 9 kg Zn/ha but from the economic point of view 3 kg Zn/ha may be recommended. However, from the regression analysis a quadratic relationship also found between yield and added zinc (Fig.6). The optimum level of Zn was calculated from the quadratic equation as 6.28 kg Zn/ha to get the maximum yield (3.50 t/ha). Therefore, 6.28 kg Zn/ha might be recommended for the wheat cultivation in Sonatola series under Grey Floodplain Soil.

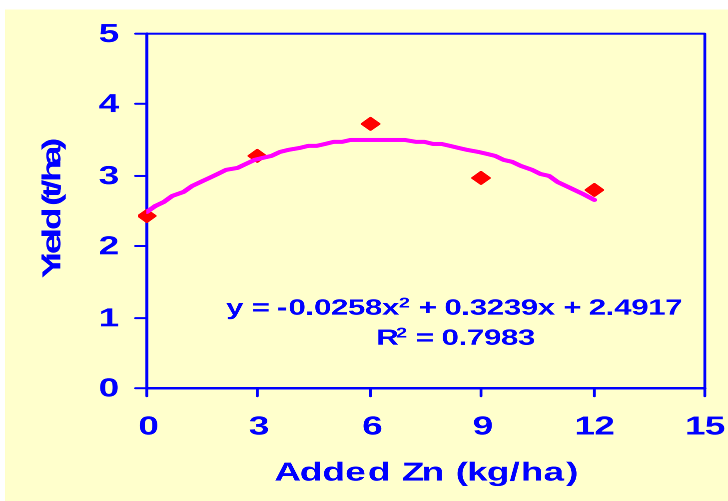

Fig No.6: Response of wheat to added Zn in Sonatola series

Sara

The grain yield was significantly increased upto 12 kg/ha Zn/ha and the order of the yield was Zn_{12}>Zn_9>Zn_6 >Zn_3>Zn_0. The highest yield (5.47 t/ha) was recorded in T_5 (12 kg Zn/ha) which was significantly higher over all other treatments except T_4 where the second highest dose was applied (Table1). The data showed a linear relationship. The regression line was Y = 4.11 + 0.129x and R^2 = 0.8366 (Fig. 7). The increase in grain yield was due to application of Zn in 95% cases. The regression line was linear, as such the confidence interval test was done and it was found that the grain yield was increased between 23.00 to 234.99 kg/ha by the application of l kg Zn/ha within the ranges from 0 to 12 kg Zn/ha.

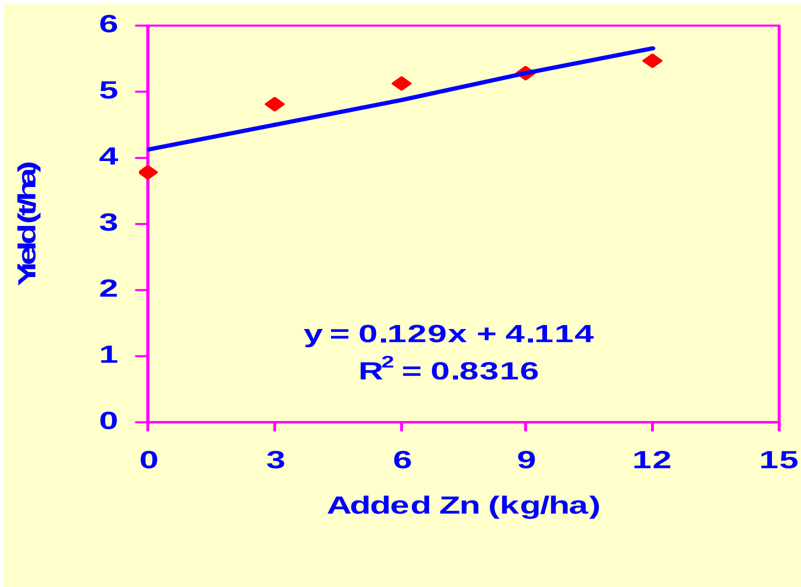

Fig No.7: Response of wheat to added Zn in Sera series

Ishurdi

The grain yield was significantly increased upto 12 kg Zn/ha and the order of the increase was Zn_{12}>Zn_9>Zn_6 >Zn_3>Zn_0. The highest yield (5.50 t/ha) was recorded both in T_5 (12 kg Zn/ha) and T_4 (9 kg Zn/ha) which was significantly higher over all other treatments (Table1). The data showed a linear relationship (Fig. 8). The regression line was Y = 4.52 + 0.09X and R^2= 0.944. The increase in grain yield was due to application of Zn in 94% cases. The regression line was linear, as such the confidence interval test was done and it was found that the grain yield was increased between 14.39 to 165.56 kg/ha by the application of l kg Zn/ha with in the ranges from 0 to 12 kg Zn/ha.

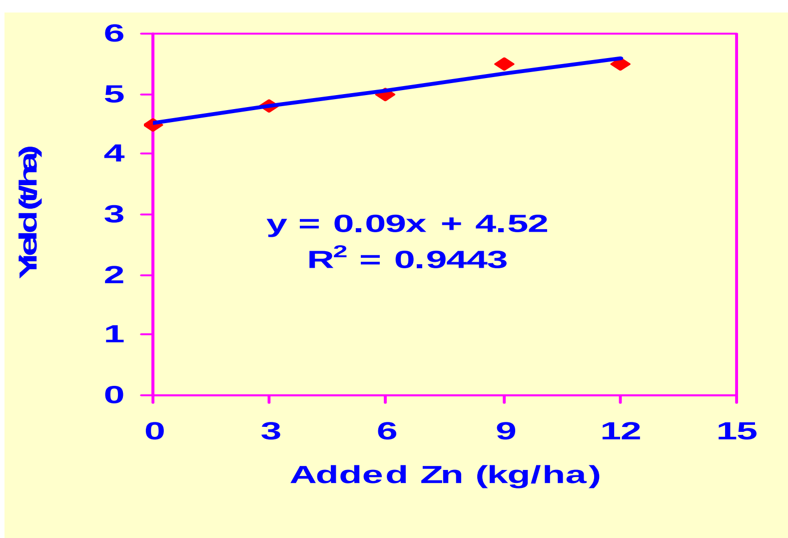

Fig No.8: Response of wheat to added Zn in Ishurdi series

Gopalpur

The grain yield of wheat was significantly increased upto 12 kg/ha Zn/ha and the order of the increase was $Zn_{12}>Zn_9>Zn_6>Zn_3>Zn_0$. The highest yield (5.13 t/ha) was recorded in T_5 (12 kg Zn/ha), which was significantly higher only over absolute control, Zn control and the lowest dose (3 kg Zn/ha) (Table1). The data showed a linear relationship and regression line was Y = 4.471 + 0.059 X and R^2 = 0.8576 (Fig. 9). The increase in grain yield was due to application of Zn in 90% cases. The regression line was linear, as such the confidence interval test was done and it was found that the grain yield was increased between 15.35 to 102.65 kg/ha by the application of l kg Zn/ha within the ranges from 0 to 12 kg Zn/ha respectively.

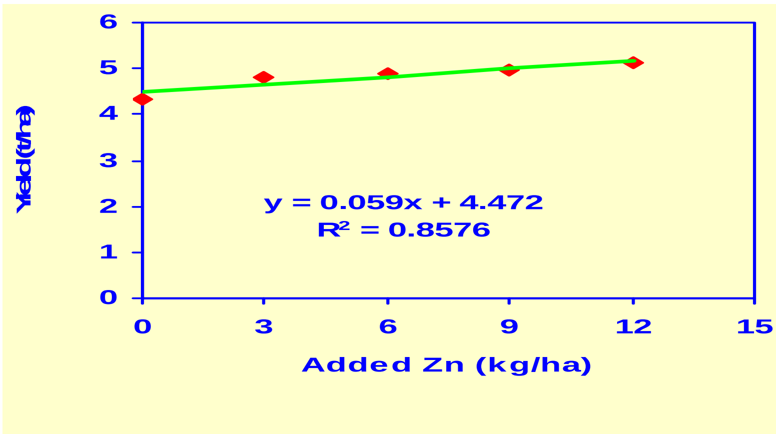

Fig No.9: Response of wheat to added Zn in Gopalpur series

Darsona

The grain yield of wheat was significantly increased upto 12 kg/ha Zn/ha and the order of the increase was $Zn_{12}>Zn_9>Zn_6>Zn_3>Zn_0$. The highest yield (2.91 t/ha) was recorded in T_5 (12 kg Zn/ha) which was significantly higher over all other treatments except T_4 and T_3 (Table 2a). The data showed a linear relationship and regression line was Y = 2.436 + 0.0447 Xand R^2 = 0.9783 (Fig. 10). The increase in grain yield was due to application of Zn in 99% cases. The regression line was linear, as such the confidence interval test was done and it was found that the grain yield was increased between 31.81 to 51.52 kg/ha by the application of l kg Zn/ha within the ranges from 0 to 12 kg Zn/ha respectively.

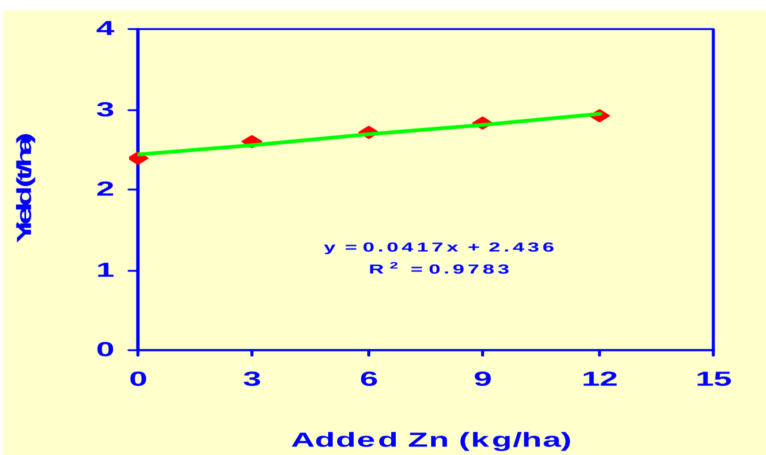

Fig No.10: Response of wheat to added Zn in Darsona series

Table 1. Grain yield of wheat as influenced by Zn fertilization

Treat-ent Added Zn (kg/ha)	Name of the soil series									
	Amnura	Nachole	Lauta	Ganga-chara	Kaunia	Sonatola	Sara	Ishurdi	Gopal-pur	Darsona
	Grain yield (t/ha)									
T0 (*)	2.17c	1.56b	1.65c	3.27d	1.94e	1.59d	3.33c	2.70d	2.30d	0.73d
T1 (Zn0)	3.50b	2.34b	2.66b	4.28c	2.42d	2.43c	3.77c	4.50c	4.33c	2.40c
T2 (Zn3)	3.57ab	2.58ab	3.47a	4.90b	3.50b	3.28ab	4.80b	4.80bc	4.80b	2.59bc
T3 (Zn6)	3.87a	3.07a	3.67a	5.58a	3.92a	3.73a	5.13ab	5.00b	4.90ab	2.71ab
T4 (Zn9)	3.29b	2.39b	2.73b	4.50bc	3.13c	2.97abc	5.27ab	5.50a	4.97ab	2.82a
T5 (Zn12)	3.20b	2.29b	2.65b	4.12c	2.98c	2.80bc	5.47a	5.50a	5.13a	2.91a
LSD(.05)	0.347	0.644	0.484	0.417	0.327	0.793	0.470	0.383	0.295	0.216
CV (%)	4.07	10.52	6.67	3.60	4.29	10.94	3.90	3.20	2.56	3.44

Zinc content in grain and straw of wheat

The content of zinc in the grain and straw of wheat are given in (Table 2a & 2b).

Grey Terrace Soil

Applied zinc significantly influenced the zinc content in both the grain and straw. The content in straw was found higher than grain in almost all cases but this variation was narrowed down with the highest rates of Zn (> 9 kg/ha). The highest Zn content was obtained where 6 kg Zn/ha was applied which was significantly higher over all other treatments the lowest was found where zinc was not applied (Tables 2a & 2b). The content of zinc in grain was varied from 22 to 37 ppm while in straw that was 29-39 ppm but the trend of variation among the treatments remained alike in almost all the series under this soil.

Non Calcareous Dark Grey and Brown Floodplain Soil

The content of Zn in grain of wheat grown in this soil was varied form 21-39 ppm (Table 2a). The highest Zn content was obtained with T_3 (6 kg Zn/ha), which was significantly higher over all other treatments. The lowest content was of course found in T_1 (Zn_0). The treatments followed the order of $Zn_6 > Zn_9 > Zn_{12} > Zn_3 > Zn_0$ in respect of Zn content. In case of straw, the Zn content varied from 28-41 ppm (Table 2b). The trend of variation and treatment differentiation was found similar to grain content.Verma and Tripathi (1983) observed that only 5 ppm of added Zn increased the grain and straw yields when Fe was not applied, but when Fe was applied, even 10 ppm of added Zn responded significantly. The grain and straw yields were higher in the presence of $CaCO_3$ than its absence. The concentration of zinc increased with the application of Fe. The rice straw contained the highest concentration of Zn (20.1 ppm), whereas rice grain contained lowest (14.3 ppm). The Fe concentration in rice plants increased with increasing levels of applied Zn. The highest concentration (343 ppm) of Fe was recorded in rice straw and lowest in rice grains (165 ppm). The concentrations of Zn and Fe were lower in the presence of $CaCO_3$ than in its absence. When more Zn was applied, less Zn was translocated to grains. The effects of Fe and Zn on Fe distribution at maturity were opposite to that of Zn distribution.

Calcareous Soil

In Calcareous Soil, the content of zinc in grain was gradually increased with the increasing levels of zinc application (Table 2a). The result varied from 24-44 ppm. The highest content of Zn in grain was obtained in T_5 (12 kg Zn/ha) which was significantly higher over rest of the treatments. The lowest content was recorded with zinc control treatment. Similar trend was observed incase of straw. However, the content of Zn in straw was varied from 31-52 ppm (Table 2b). Iyengar and Deb (1976) reported that DTPA, like EDTA (NH4)2 CO_3 could extract water-soluble, exchangeable, complexed and portions of precipitated Zn fractions. This extractant removes Zn from the labile pool of Zn in soils (Lopez and Graham 1972). There are many reports which support DTPA as a better extractant for assessing plant available Zn from a wide range of soils. In a greenhouse trial with corn grown on 92 soils (pH 7.0-8.2), Barrow *et al.* (1971) observed that DTPA was a better extractant in predicting plant response to Zn compare to dithizone, EDTA or HCL. Singh and Singh (1981) also reported that DTPA gave a better correlation than other extractants with Bray's percent yield and Zn uptake by plants. Iyengar and Deb (1976) tested 11 extractants on 10 soils and found, DTPA, NH4OAC and EDTA-extractable gave the best correlations with Zn uptake by corn and mungbean. Haq *et al* (1972) also showed that, of 4 extractants tested, DTPA gave the highest correlations with Zn concentration in corn. However, some contradictory reports on the merits of DTPA are also available. Zinc concentrations in corn and oat grown on 27 soils best correlated with the amounts extracted by acidic NH4OAC rather than DTPA (John, 1972).

Table 2a. Concentration of Zn content (ppm) in wheat grain as influenced by different **rates of applied Zn in different soil series of Bangladesh.**

Treat-ment Added Zn (kg/ha)	Name of the soil series									
	Grey Terrace Soils			Non Calcareous Dark Grey Floodplain & Brown Floodplain Soil			Calcareous Soil			
	Amnura	Nachole	Lauta	Ganga-chara	Kaunia	Sona-tola	Sara	Ishurdi	Gopal-pur	Darsona
T1 (Zn0)	24.93d	22.10d	22.93d	26.00d	21.27e	23.93d	26.93e	27.93e	26.50e	23.83e
T2 (Zn3)	32.07c	30.47c	31.33c	33.93c	28.57d	30.33e	34.93d	35.50d	34.57d	33.00d
T3 (Zn6)	37.07a	35.67a	36.00a	38.67a	34.60a	36.43a	38.97c	39.40c	38.67c	38.33c
T4 (Zn9)	33.67bc	33.40d	33.63b	35.67b	32.93b	33.50b	41.13b	41.43b	41.47b	40.67b
T5 (Zn12)	34.00b	32.50b	32.33bc	34.00c	31.17c	31.00c	44.33a	44.33a	44.43a	42.80a
CV (%)	1.80	2.10	1.40	1.60	1.50	1.70	1.40	2.00	1.20	1.60

Table 2b. Concentration of Zn content (ppm) in wheat straw as influenced by different rates of applied Zn in different soil series of Bangladesh.

Treat-ment Added Zn (kg/ha)	Name of the soil series									
	Grey Terrace Soils			Non Calcareous Dark Grey Floodplain & Brown Floodplain Soil			Calcareous Soil			
	Amnura	Nachole	Lauta	Ganga-chara	Kaunia	Sona-tola	Sara	Ishurdi	Gopal-pur	Darsona
T1 (Zn0)	31.90d	29.23c	30.27d	32.90d	28.27d	31.27d	33.27e	34.00e	34.03e	31.17e
T2 (Zn3)	35.93b	33.77b	34.67b	37.17b	32.93bc	35.43b	38.00d	39.00d	38.13d	35.93d
T3 (Zn6)	38.80a	31.17 a	38.33a	40.60a	37.00a	38.57a	41.30c	41.40c	41.80c	39.93c
T4 (Zn9)	33.60c	33.50b	34.00bc	36.60b	33.83b	34.27c	48.03b	48.60b	47.63b	44.50b
T5 (Zn12)	32.73cd	32.93b	31.10c	34.17c	32.17c	31.23d	51.07a	52.00a	51.27a	50.17a
CV (%)	1.40	1.90	1.50	1.30	1.50	1.20	1.50	1.30	1.40	1.30

Photograph: Response of wheat to zinc in calcareous soil at Ishurdi.

SUMMARY AND CONCLUSION

The grain yield of wheat increased significantly due to application of Zn in all the soils under study. However, the requirement of zinc for wheat varied from soil to soil. The optimum amount of zinc was estimated from the quadratic response curve as 4.46, 5.67, 198 5.45, 5.60, 6.43 and 6.28 kg Zn/ha for Amnura, Nachole, Lauta under Deep Gray Terrace Soil, Gangachara, Kaunia, Sonatola under Gray Floodplain Soil respectively. The grain yield of wheat was significantly increased up to 12 kg Zn/ha and showed linear relationship with the added zinc in Calcareous Dark Grey and Brown Floodplain Soils which were alkaline in reaction. The grain yield was increased 23-234 kg/ha, 14-166 kg/ha, 15-103 kg/ha & 32-52 kg/ha by the application of 1 kg Zn/ha within the range from 0-12 kg Zn/ha for Sara, Ishurdi, Gopalpur and Darsona series respectively under the same soil.

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