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Direct and residual effect of Zinc and FYM on quality and uptake of N, P, and K in pearl millet-wheat cropping system

Anand Pathak, Akhil Gupta, Apoorv Tiwari and Vipin Kumar

Abstract
Different doses of Zinc (kg/hectare) and FYM (ton/hectare) were applied in pearl millet-wheat sequence to assess the uptake of Nitrogen, Phosphorus and Potassium in two consecutive years. The maximum values of nitrogen content in pearl millet grain and stover was recorded at 7.5 kg Zn + 5 t FYM/ha treatment in both crop seasons. The maximum values of N content in wheat grain and straw were recorded under 5 t FYM/ha + 10 kg Zn/ha treatment in both crop seasons. Application of 5t FYM/ha increased the P content in grain and stover over control in both the years. The phosphorus content in crop was further improved with combined application of FYM and zinc. The maximum values of P content in pearl millet grain and stover were recorded under 5 t FYM/ha + 5 kg Zn/ha whereas in case of wheat it was at 5 t FYM/ha + 7.5 kg Zn/ha. in both crop seasons. The various levels of zinc in combination with 5 t FYM/ha resulted in significantly higher uptake of K in the crop in both crop seasons over zinc alone. The highest uptake of K (15.5 kg/ha in grain and 189*.7 kg/ha in stover) was recorded under 5 t FYM/ha + 7.5 kg Zn/ha treatment in pearl millet. The effect of this combination was found to be statistically at par with 5 t FYM/ha+ 5 kg Zn/ha treatment. In case of wheat the uptake of Potassium almost similar pattern was observed at 5 kg Zn + 5 t FYM/ha and 7.5 kg Zn + 5 t FYM/ha doses. The direct applications of Zn along with FYM and its residual amount improved the yields of pearl millet and wheat as well as uptake of Nitrogen, Phosphors and Potassium in both crops.

Keywords: Nitrogen, Phosphorus, Potassium, Zinc, FYM

1. Introduction
Zinc can affects the translocation and transport of Phosphorus in plants. Under Zn deficiency, excessive translocation of P occurs resulting in P toxicity. If Zinc is not translocated within the plant, symptoms first appear on the younger leaves and other plant parts. Common symptoms of zinc deficiency, which generally occurs, are stunted growth poor tillering, development of light green yellowing bleached spots, chlorotic bands on either side of the midrib in the plants. Zinc was recently assumed great importance in crop production as it plays a significant role in oxidation and reduction process. Qualitative and quantitative importance of zinc application to several crops has been well established in literature (Sharma and Singh, 1990) [9]. In many parts of India, zinc as a plant nutrient now stands third in importance next to nitrogen and phosphorous. The soils of Agra region vary in texture from sandy to clay loam, alkaline in nature, low in organic carbon content and generally quite low in fertility status. Zinc deficiency to the extent of 80 percent has been observed in the intensively cropped alluvial soil of Uttar Pradesh (Tiwari *et al*., 1995) [14], where pearl millet-wheat cropping sequences predominate.
The application of FYM is found to influence the pore space, permeability to water and air, structure formation and some other physical properties. It reduces the soil erosion. Farm yard manure increases the humas content of soils at least temporarily and consequently the water holding capacity of sandy soils is increased and the drainage of clayey soils is improved. FYM provides food for soil micro-organisms. Addition of organic matter may help in increasing nutrients availability both from applied and native sources. Hence, the present study was undertaken with a view to study the integrated effect of FYM and zinc on pearl millet and wheat productivity. Even with the application of recommended dose of fertilizers yield potential of this sequence (Cereal-cereal) has reached to plateau because of deterioration in soil health. Pearl millet-wheat sequence is predominant in north-western plain zone and central zone of India. In sustainable crop production, organic manuring plays an important role.

The response of soil applied zinc and FYM could be more correctly assessed on cropping system basis rather than on a single crop basis. No information is available for the optimum dose and residual effect of zinc fertilizer application in uptake of Nitrogen, Phosphorus and Potassium for pearl millet-wheat system practiced in south western plain, zone of Uttar Pradesh. The present investigation was undertaken to assess the direct and residual effect of Zn and FYM in the uptake of N, P and K on pearl millet and wheat crops.

Material and Methods

To evaluate the effect of zinc with and without FYM on pearl millet-wheat cropping system, the investigation was carried out at research farm R.B.S. College, Bichpuri, Agra during kharif and rabi seasons of 2008-09 and 2009-10. The details of the materials used and procedures employed in these studies are described in the ensuring text. The soils in this tract owe their origin to the alluvium deposited by the two rivers, the Ganga and the Yamuna, belonging to Pleistocene age. The alluviums can be divided into two sub-groups: (i) Old (Pleistocene) alluvium known as Bangar and (ii) recent alluvium known as khadar.

The climate of Agra district on the whole is hot and dry. The summers are full of desiccating winds and scorching heat. The mean annual rainfall for this district is around 65 cm. However, a few showers commonly occur during winter season and sometimes fog and frost are also experienced.

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Experimental site: The experiment was carried out in plot B-12b of the Raja Balwant Singh College, Research Farm, Bichpuri (Agra) during both the years. The field had received no zinc in the past history of cropping and management. The site of this experiment is situated about 11 kms away from Agra city and located at Agra-Bharatpur road.

Experimental details Field experiments for two consecutive years were carried out with following treatments:

1. Control
2. 2.5 kg Zn/ha
3. 5 kg Zn/ha
4. 7.5 kg Zn/ha
5. 10 kg Zn/ha
6. 5 t FYM/ha
7. 2.5 kg Zn + 5 t FYM/ha
8. 5 kg Zn + 5 t FYM/ha
9. 7.5 kg Zn + 5 t FYM/ha

Crop	:	Pearl millet-wheat crop sequence
Replication	:	4
Design	:	RBD

Preparation of the experimental field and fertilizer applications

The experimental field was prepared by a deep tractor ploughing and disking and finally laid out in to plots leaving irrigation channels and bunds in between the treatments.

Nitrogen, phosphorus and potassium were applied through urea, di-ammonium phosphate and muriate of potash, respectively. Recommended doses of NPK for pearl millet (120, 60, 40 kg/ha) and wheat (150, 60 and 40 kg/ha) were applied at the time of sowing. Zinc was applied through zinc sulphate as per treatments at the time of sowing in pearl millet only. Well decomposed FYM was applied as per treatments 15 days before sowing of both the crops.

Seed and sowing of Pearl millet and Wheat

The seeds of pearl millet were sown in lines at 30 cm apart, using the seed rate of 5 kg/ha in the month of July in both years. The lines were opened by pointed spade by human labour. After sowing, planking was done to cover the seed.

The seeds of wheat were sowing in lines at 20 cm apart, using a uniform seed rate of 125 kg/ha in the month of November during both the years. The lines were opened by pointed spade by human labour. After sowing, planking was done to cover the seed.

The crops were irrigated at the proper time as judged by the appearance of soil and the crop. The source of irrigation water was canal.

Observations

At harvest, the grain and straw/stover yields of the crops were recorded.

Chemical analysis

The grain and straw samples were dried in sun followed by in oven at 70 °C for 5 hours. They were then ground in a Wiley's mill and stored in wide mouth glass stoppered bottles with proper labelling. The following determinations were made from the well-prepared plant materials.

Nitrogen -Nitrogen content in grain and straw samples was determined by Kjeldahl method.

Phosphorous -The phosphorus in grain and straw samples was determined by ammonium molybdate vanadate yellow colour method as described by Chapman and Pratt (1961) in di-acid extract.

Potassium -Potassium was estimated in the same extract after making suitable dilution and concentration was measured with the help of flame photometer.

Uptake studies -The uptake of nitrogen, phosphorus, and potassium, by the crops was computed by multiplying contents of the elements with the yield data.

Chemical analysis of soil samples

Soils samples collected after harvest of both the crops were analyzed for their properties.

Available nitrogen -Alkaline permanganate method (Subbiah and Asija, 1956) [13] was adopted for the determination of available nitrogen.

Available phosphorus – It was determined per method of Olsen *et al.* (1954) [8].

Available potassium – Available K was extracted from the soil with normal neutral ammonium acetate (Hanway and Heidal, 1952) [6] and determined flame photometrically.

Statistical analysis

The data regarding yield, chemical composition and nutrients uptake were processed and 1353nalysed statistically to test whether the effects of different treatments were significant or not. Fisher 'F' test was applied for this purpose. The interpretation of the results is based on statistical significance of calculated 'F' values at 5% level. Critical difference (C.D.) has been worked out for comparing the differences between the levels of significant treatments.

Result and Discussion

The results of the present investigations were obtained for yield, quality parameters of the crops, uptake studies and soil fertility are presented and discussed are as follows

Nutrient Uptake Analysis

(A) Pearl millet

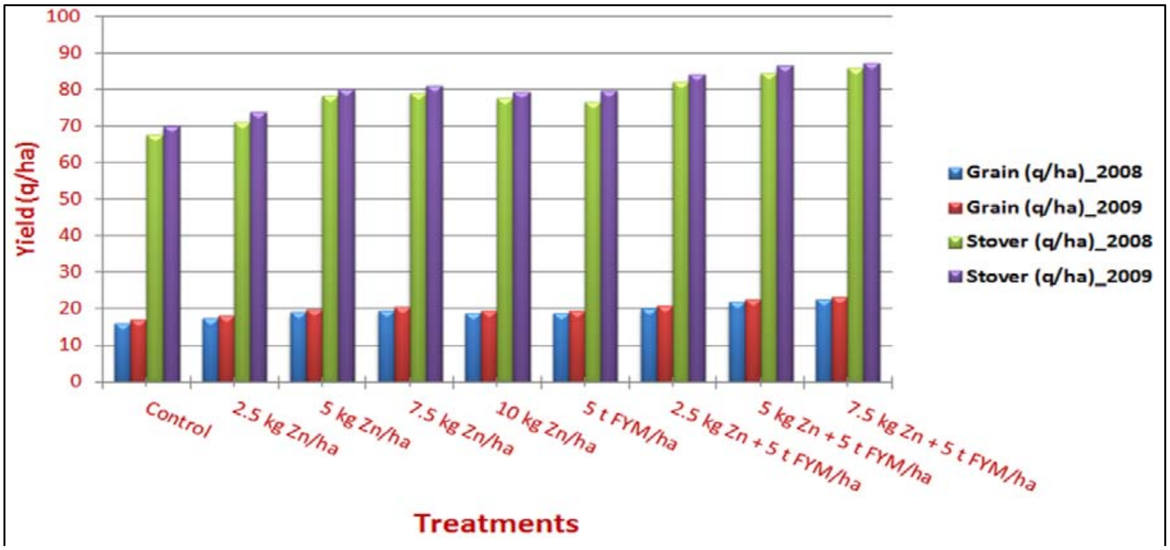

Fig 1: Effect of various treatments on yields of pearl millet

Content and uptake of Nitrogen in pearl millet crop

Data on nitrogen content and uptake in pearl millet crop as affected by various treatments are presented in Table 1. A study of the data indicate that the application of zinc enhanced the nitrogen content in pearl millet grain and stover significantly over control in both the crop seasons. Addition of zinc (10 kg/ha) increased the nitrogen content in grain and stover from 1.78 to 1.85 and 0.51 to 0.56 per cent, respectively during 2008. The corresponding increases in N content in 2009 were from 1.80 to 1.87 and 0.53 to 0.58 per cent. This increase may be due to the favourable effect of zinc on metabolic processes. Gangwar and Singh (1988) [4] also reported increased nitrogen content of grain and stover with zinc application. Among the zinc levels, addition of 10 kg Zn/ha proved superior in respect of nitrogen absorption by the crop in both the crop seasons. Addition of 5 t FYM/ha also improved the nitrogen content in grain and stover in both crop seasons. The nitrogen content in crop was further improved when Zn levels were incorporated with 5 t FYM/ha. The maximum values of nitrogen content in grain and stover was recorded at 7.5 kg Zn + 5 t FYM/ha treatment in both crop seasons.

Table 1: Effect of various treatments on content and uptake of nitrogen by pearl millet grain and stover

Treatment	N content (%)				N uptake (kg/ha)			
	Grain		Stover		Grain		Stover	
	2008	2009	2008	2009	2008	2009	2008	2009
Control	1.78	1.80	0.51	0.53	28.5	30.4	34.4	37.1
2.5 kg Zn/ha	1.80	1.81	0.52	0.54	31.0	36.3	36.9	39.8
5 kg Zn/ha	1.82	1.83	0.54	0.55	34.7	36.3	42.2	44.0
7.5 kg Zn/ha	1.83	1.85	0.55	0.57	35.8	37.7	43.5	46.2
10 kg Zn/ha	1.85	1.87	0.56	0.58	34.7	36.2	43.4	46.0
5 t FYM/ha	1.86	1.88	0.57	0.60	34.6	36.3	43.7	47.7
2.5 kg Zn + 5 t FYM/ha	1.88	1.90	0.58	0.61	37.7	39.4	47.7	51.2
5 kg Zn + 5 t FYM/ha	1.90	1.91	0.60	0.63	41.4	43.0	50.7	54.5
7.5 kg Zn + 5 t FYM/ha	1.92	1.93	0.62	0.64	43.4	44.8	53.3	55.8
SEm±	0.006	0.005	0.005	0.006	1.45	1.38	1.61	1.72
CD (P=0.05)	0.017	0.014	0.014	0.017	4.23	4.02	4.70	5.02

Removal of N by grain and stover of pearl millet crop was increased with up to 7.5 kg Zn/ha addition (Table 1). Nitrogen uptake by grain and stover increased from 28.5 to 35.8 and from 34.4 to 43.5 kg/ha with 7.5 kg Zn/ha in 2008, respectively. The corresponding increases during 2009 were from 30.4 to 37.7 and from 37.1 to 46.2 kg/ha. The increases in N uptake my be due to increase in N content and grain and stover yield due to zinc application. Melawar *et al.* (2001) [7] also reported similar results. Application of 5 t FYM/ha also increased the uptake of nitrogen by pearl millet crop over control in both the years. The nitrogen uptake by the crop improved significantly with combined application of 5 t FYM/ha and zinc levels (2.5 to 7.5 kg/ha) in both the years. The maximum nitrogen uptake was associated with treatment of 5 t FYM + 7.5 kg Zn/ha. This might be due to better availability of nitrogen as a result of FYM application. The favourable influence of FYM application to soil for higher removed of N by pearl millet was also reported by Singh *et al.* (1994) [11].

Phosphorus: A study of Table 2 reveals that the lower levels of zinc increased the P content in grain and stover over control in both crop seasons. The maximum values of P content in grain and straw were recorded with 2.5 kg Zn/ha. Application of 10 kg Zn/ha tended to decrease the P content in grain and stover in both crop seasons and this reduction in P content was significant over 5 kg Zn/ha. This reduction in P content may be due to hindrance caused by increased concentration of zinc in the absorption and translocation of P from the roots to the above ground parts. Excess of zinc may also change the physiological availability of plants to absorb P either by changing the permeability of cell wall or due to some unknown mechanisms. Application of 5 t FYM/ha increased the P content in grain and stover over control in both the years. The phosphorus content in crop was further improved with combined application of FYM and zinc. The maximum values of P content in pearl millet grain and stover were recorded under 5 t FYM/ha + 5 kg Zn/ha in both crop seasons. This favourable effect of FYM on P availability to plants is due to solubilizing effect on fixed form of P in soil. Tek Chand and Tomar (1992) [15] reported similar results.

Table 2: Effect of various treatments on content and uptake of phosphorus by pearl millet grain and stover

Treatment	P content (%)				P uptake (kg/ha)			
	Grain		Stover		Grain		Stover	
	2008	2009	2008	2009	2008	2009	2008	2009
Control	0.23	0.24	0.12	0.13	3.7	4.0	8.1	9.1
2.5 kg Zn/ha	0.23	0.25	0.13	0.14	3.9	4.5	9.2	10.3
5 kg Zn/ha	0.24	0.25	0.14	0.15	4.6	4.9	10.9	12.0
7.5 kg Zn/ha	0.23	0.24	0.13	0.14	4.5	4.9	10.2	11.3
10 kg Zn/ha	0.22	0.23	0.13	0.13	4.1	4.4	10.0	10.3
5 t FYM/ha	0.26	0.27	0.15	0.16	4.8	5.2	11.5	12.7
2.5 kg Zn + 5 t FYM/ha	0.27	0.29	0.17	0.18	5.4	6.0	13.9	15.1
5 kg Zn + 5 t FYM/ha	0.29	0.30	0.18	0.19	6.3	6.7	15.2	16.4
7.5 kg Zn + 5 t FYM/ha	0.29	0.29	0.18	0.19	6.5	6.7	15.5	16.5
SEm±	0.003	0.004	0.004	0.003	0.31	0.34	0.85	0.81
CD (P=0.05)	0.008	0.011	0.011	0.008	0.90	0.99	2.48	2.36

Application of 2.5 kg Zn/ha tended to increase the P uptake by pearl millet grain and stover significantly over control in both crop seasons (Table 2). The increase in P uptake may be ascribed to increased grain and stover production. Similar results were reported by Gupta *et al.* (1985) [5]. Phosphorus uptake by the crop decreased at higher levels of Zn (5 and 10 kg Zn/ha) over 2.5 kg Zn/ha in both crop seasons. The results indicate an antagonistic relationship between P and Zn on P nutrition of the crop. Application 5 t FYM/ha alone or in combination with zinc increased the P uptake by wheat crop significantly over control in both crop seasons. The maximum values of P uptake by grain and stover were recorded under 5 t FYM/ha + 7.5 kg Zn/ha treatment in both crop seasons. This may be due to more availability of P from applied P and to the solubility action of organic acids produced during degradation of FYM thus, resulting in more release of the native and added P in soil. Dahiya *et al.* (1980) [3] reported that the addition of FYM increased the P uptake in crop.

Potassium: A further study of Table 3 reveals that the lower levels of zinc application tended to increase the K content in pearl millet grain and stover significantly in both the crop seasons. There was a gradual reduction in K content with higher levels of Zn (10 kg Zn/ha) over 7.5 kg Zn/ha treatments. Application of 5 t FYM/ha significantly increased the K content in pearl millet grain and stover over control in both crop seasons. Conjoint use of FYM and zinc further improved the K content in pearl millet grain and stover significantly over Zn alone. Significantly highest content of K was recorded with 5 t FYM/ha + 7.5 kg Zn/ha treatment during 2008 and 2009, which was statistically at par with 5 t FYM/ha + 5 kg Zn/ha treatment. This increase in K content might be du to favourable influence of organic matter on K absorption by the crop. Similar results were reported by Dahiya *et al.* (1980) [3].

The data (Table 3) reveals that the uptake of K by pearl millet grain and straw increased with zinc application in both the crop seasons. The increase in K uptake by grain and straw was significant with 7.5 kg Zn/ha. The higher of Zn (10 kg/ha) tended to decline K continent in the crop over 7.5 kg Zn/ha in both crop seasons but this reduction was non-significant. Application of FYM alone improved the utilization of K by pearl millet crop significantly over control. The various levels of zinc in combination with 5 t FYM/ha resulted in significantly higher uptake of K in the crop in both crop seasons over zinc alone. The highest uptake of K (15.5 kg/ha in grain and 189*.7 kg/ha in stover) was recorded under 5 t FYM/ha + 7.5 kg Zn/ha treatment. The effect of this combination was found to be statistically at par with 5 t FYM/ha+ 5 kg Zn/ha treatment. This increase in K uptake by pearl millet crop might be due to higher yields of crop in FYM treatment plots which is very much in agreement with the findings of Dahiya *et al.* (1980) [3] and Singh and Tomar (1991) [12].

Table 3: Effect of various treatments on content and uptake of potassium by pearl millet grain and stover

Treatment	K content (%)				K uptake (kg/ha)			
	Grain		Stover		Grain		Stover	
	2008	2009	2008	2009	2008	2009	2008	2009
Control	0.60	0.62	2.10	2.12	9.6	10.4	141.8	148.5
2.5 kg Zn/ha	0.60	0.63	2.12	2.13	10.3	11.4	150.6	157.2
5 kg Zn/ha	0.62	0.64	2.13	2.15	11.8	12.7	166.6	172.1
7.5 kg Zn/ha	0.62	0.64	2.14	2.16	12.1	13.0	169.3	175.2
10 kg Zn/ha	0.61	0.63	2.12	2.14	11.4	12.2	164.5	170.0
5 t FYM/ha	0.63	0.64	2.14	2.16	11.7	12.3	164.2	171.7
2.5 kg Zn + 5 t FYM/ha	0.64	0.66	2.15	2.17	12.8	13.7	176.7	182.3

5 kg Zn + 5 t FYM/ha	0.66	0.67	2.17	2.19	14.4	15.0	183.4	189.4
7.5 kg Zn + 5 t FYM/ha	0.67	0.68	2.18	2.20	15.1	15.8	187.6	191.8
SEm±	0.009	0.007	0.011	0.012	0.68	0.66	3.07	2.97
CD (P=0.05)	0.026	0.020	0.032	0.035	1.98	1.92	8.96	8.67

(B) Residual effect on wheat

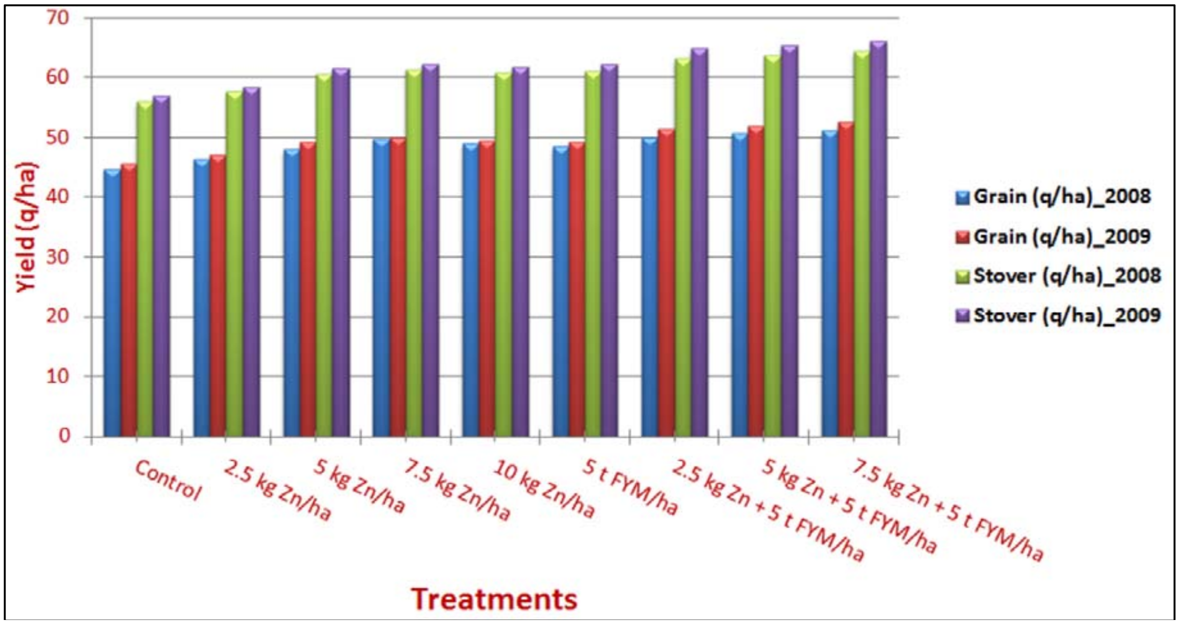

Fig 2: Residual effect of different treatments of zinc with and without FYM on grain and straw yield of wheat

A further study of above figure (Fig 2) indicates that the straw yield of wheat varied from 55.90 to 64.35 and 57.00 to 66.23 q/ha in different treatments during first and second year, respectively. The straw yield response varied from 7.75 to 8.45 q/ha in 2008-09 and from 1.50 to 9.23 q/ha in 2009-10. The residual effect of zinc was significant up to 7.5 kg Zn/ha with respect to wheat yield. Residual effect of 5 t FYM/ha was beneficial in improving the straw production of wheat in both crop seasons. The effect of combined use of FYM and Zn levels in each year was superior to control. The higher straw yield (mean 65.25 q/ha) was noted in treatment receiving 5 t FYM/ha + 7.5 kg Zn/ha than in 7.5 kg Zn/ha alone treatment. Dahiya *et al.*, 1980) [3] reported similar results.

Content and uptake of nutrients in wheat

Nitrogen: Zinc application in preceding pearl millet crop increased the nitrogen content (Table 4) in wheat grain and straw significantly over control in both years. The beneficial effect of Zn on nitrogen content was statistically significant. Nitrogen content in grain and straw increased from 2.20 to 2.31 and 0.62 to 0.71% and from 2.22 to 2.33 and 0.63 to 0.72% with 10 kg Zn/ha level in first and second year, respectively. Arya *et al.* (2000) [1] reported similar effect of zinc on nitrogen concentration in wheat. It is seen from the data that the application of FYM enhanced the content of nitrogen in wheat grain and straw significantly over control during both the years of study. The mean nitrogen content in grain increased from 2.20 to 2.25 per cent and from 2.22 to 2.27 per cent with the addition of 5 t FYM/ha in first and second year, respectively. The corresponding increases in N content in straw were from 0.62 to 0.66 and 0.63 to 0.67 per cent. This significant effect of FYM application on N content may be due to the fact that FYM itself contains N and upon its decomposition produces many organic acids which in turn make the insoluble N soluble and thus increases N availability. Dahiya *et al.* (1980) [3] and Singh *et al.* (1994) [11] also reported increased nitrogen content in wheat crop was further improved when FYM was used with Zn levels. The maximum values of N content in wheat grain and straw were recorded under 5 t FYM/ha + 10 kg Zn/ha treatment in both crop seasons.

Table 4: Residual effect of various treatments on nitrogen content and uptake by wheat grain and straw

Treatment	Nitrogen continent (%)				Nitrogen uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	2008	2009	2008	2009	2008	2009	2008	2009
Control	2.20	2.22	0.62	0.63	98.4	101.2	34.6	35.9
2.5 kg Zn/ha	2.22	2.24	0.64	0.65	103.1	105.6	36.9	38.02
5 kg Zn/ha	2.25	2.27	0.66	0.67	108.0	111.6	39.9	41.3
7.5 kg Zn/ha	2.26	2.28	0.67	0.68	112.2	113.7	41.1	42.3
10 kg Zn/ha	2.26	2.29	0.68	0.69	110.7	113.3	41.3	42.6
5 t FYM/ha	2.25	2.27	0.66	0.67	109.1	111.9	40.3	41.7
2.5kg Zn + 5 t FYM/ha	2.28	2.29	0.69	0.70	114.0	117.9	43.6	45.3
5 kg Zn + 5 t FYM/ha	2.30	2.32	0.70	0.70	116.3	120.6	44.6	45.8
7.5 kg Zn + 5 t FYM/ha	2.31	2.33	0.71	0.72	118.0	122.4	45.6	47.6

SEm	0.006	0.007	0.004	0.004	1.76	1.67	0.65	0.44
CD (P = 0.05)	0.017	0.020	0.011	0.011	5.17	4.89	1.89	1.30

A further study of Table 4 indicated that the application of zinc upto 7.5 kg/ha increased the N uptake by wheat grain and straw significantly over control. Nitrogen uptake by wheat crop decreased at higher levels of zinc in both crop seasons. The improvement in N uptake with Zn was mainly due to higher production of grain and straw. The maximum values of N uptake by wheat straw crop were recorded with 10 kg Zn/ha in both crop seasons. Verma *et al.* (2005) [16] also reported similar results. The results indicate that the application of FYM contributed to significant increase in N uptake by wheat grain and straw. This improvement in N uptake was mainly due to greater production of grain and straw. Higher uptake of N with FYM indicates that mineralized N from FYM could sufficiently meet the nutritional requirement of the crop. Dahiya *et al.* (1980) [3] and Singh *et al.* (1994) [11] also reported similar results. The combined application of 5 t FYM/ha long with zinc levels further enhanced the uptake of N by the crop. The maximum values of N uptake by wheat crop was noted under 5 t FYM/ha + 10 kg Zn/ha treatment with both crop seasons.

Phosphorus: The data pertaining to phosphorus content in grain and straw of wheat crop as affected by residual effect of FYM and Zn levels are presented in Table 5. The P content in wheat grain was reduced with 10 kg Zn/ha over control in both the years. But the lower levels of zinc slightly improved the P content in crop. Similar results were reported by Singh *et al.* (2004) [10]. The results indicate that FYM application in preceding crop enhanced significantly the content of phosphorus in wheat grain and straw over control. Phosphorus content in wheat grain increased from 0.22 to 0.24 per cent in first year and from 0.23 to 0.25 per cent in second year with 5 t FYM/ha. The corresponding increases in P content in straw were from 0.13 to 0.14 and 0.13 to 0.15 per cent. These results are in close agreement with the findings of Tekchand and Tomar (1992) [15]. Conjoint use of FYM and Zn further improved the P content in grain and straw and maximum values were recorded under 5 t FYM/ha + 7.5 kg Zn/ha. The higher P content may be due to solubilisation effect of organic acids produced during decomposition of FYM, improved aeration and better root proliferation.

Table 5: Residual effect of various treatments on phosphorus content and uptake by wheat grain and straw

Treatment	Phosphorus continent (%)				Phosphorus uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	2008	2009	2008	2009	2008	2009	2008	2009
Control	0.22	0.23	0.13	0.14	9.8	10.5	7.2	8.0
2.5 kg Zn/ha	0.23	0.24	0.14	0.15	10.7	11.3	8.0	8.7
5 kg Zn/ha	0.23	0.24	0.15	0.15	11.0	11.8	9.0	9.2
7.5 kg Zn/ha	0.22	0.23	0.14	0.13	10.9	11.4	8.6	8.1
10 kg Zn/ha	0.21	0.22	0.13	0.13	10.3	10.8	7.9	8.0
5 t FYM/ha	0.24	0.25	0.14	0.15	11.6	12.3	8.5	9.3
2.5 kg Zn + 5 t FYM/ha	0.25	0.26	0.15	.016	12.5	13.4	9.5	10.3
5 kg Zn + 5 t FYM/ha	0.26	0.27	0.17	0.017	13.1	14.0	10.8	11.1
7.5 kg Zn + 5 t FYM/ha	0.26	0.27	0.174	0.17	13.2	14.1	10.9	11.2
SEm	0.004	0.005	0.003	0.004	0.46	0.38	0.40	0.42
CD (P = 0.05)	0.011	0.014	0.008	0.011	1.35	1.11	1.18	1.22

A further study of Table 5 reveals that the phosphorus uptake by wheat grain and straw was not affected significantly with levels of zinc over control in both crop seasons. The lower values of P uptake by wheat grain and straw were recorded with 10 kg Zn/ha in both crop seasons. The results suggest and antagonism between zinc and phosphorus. Singh *et al.* (2004) [10] also reported a decrease in P uptake with zinc application. The results indicate a significant increase in phosphorus uptake with FYM application in preceding crop over control during both the crop seasons. The effect of FYM application in increasing phosphorus uptake may be associated with physiological stimulation of plant rather than increased ramification of root system. These results are in agreement with those reported by Dahiya *et al.* (1980) [3]. This increase in phosphorus uptake with application of FYM seems to be associated with increased P availability from applied FYM with a concomitant increased uptake of P by wheat crop in both the years. The P uptake by the crop was influenced significantly by FYM and zinc levels. The uptake of P was maximum under 5 t FYM/ha + 7.5 kg Zn/ha in both years, which was statistically at par with 5 t FYM/ha + 5 kg Zn/ha treatment.

Potassium: Data pertaining to potassium uptake by wheat grain and straw as affected by residual effect of various treatments are presented in Table 6.

Table 6: Residual effect of various treatments on potassium content and uptake by wheat grain and straw

Treatment	Potassium continent (%)				Potassium uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	2008	2009	2008	2009	2008	2009	2008	2009
Control	0.63	0.65	2.05	2.07	28.1	29.6	114.6	118.0
2.5 kg Zn/ha	0.63	0.66	2.07	2.08	29.3	31.1	119.3	121.7
5 kg Zn/ha	0.64	0.66	2.07	2.09	30.7	32.4	125.3	128.9
7.5 kg Zn/ha	0.63	0.65	2.08	2.10	31.2	32.4	127.6	130.9
10 kg Zn/ha	0.63	0.64	2.07	2.09	30.8	31.6	125.9	129.2
5 t FYM/ha	0.66	0.68	2.08	2.10	32.0	33.5	127.2	130.8
2.5 kg Zn + 5 t FYM/ha	0.67	0.69	2.09	2.11	33.5	35.5	132.0	136.7
5 kg Zn + 5 t FYM/ha	0.68	0.70	2.10	2.12	34.4	36.4	134.0	138.9

7.5 kg Zn + 5 t FYM/ha	0.38	0.70	2.10	2.12	34.7	36.8	135.1	140.4
SEm	0.008	0.007	0.006	0.008	0.25	0.27	0.98	0.96
CD (P = 0.05)	0.023	0.020	0.017	0.023	0.74	0.79	2.89	2.82

It is evident from the data that the K uptake by wheat grain and straw increased significantly upto the level of 5 kg Zn/ha compared to control during both the years. Thereafter, a reduction in K uptake was recorded at higher levels of Zn in both the crop seasons. The data indicate an increase in potassium uptake with an increase in the amount of FYM from 0 to 5 t FYM/ha. Hence, it may be concluded that the FYM application enhanced the potassium uptake by wheat grain and straw. Potassium uptake by wheat crop was further improved when Zn and FYM were applied together in preceding crop. The treatments T_8 and T_9 were at par with respect to K uptake by wheat crop. However, maximum values of K uptake were recorded under these treatments in both the years of study.

Conclusion

The emergence of Zn deficiency is largely attributed to nutrient imbalance induced by depletion of soil fertility as a result of intensive cultivation of high yielding varieties of crop plants increased use of high analysis fertilizers and decreased recycling of crop residues and animal wastes. Farm yard manure contains traces of micro-nutrients and provides food for soil micro-organisms. Applications of FYM in combination with Zn resulted in greater yield of these crops. The direct applications of Zn and its residual amount improved the yields of pearl millet and wheat uptake of nutrients and available nitrogen, phosphors, potassium and Zn after harvest of these crops.

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