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Efficacy of Zinc with and without FYM on uptake of Sulphur in pearl millet-wheat cropping system in sandy loam light textured soils

Anand Pathak, Akhil Gupta, Apoorv Tiwari and Vipin Kumar

Abstract
Pearl millet-wheat sequence is traditionally a component of the dry land system, usually grown in soils with depleted in sandy areas of northern India, where deficiency of Zn is a common problem. The yield potential of pearl millet-wheat system has reached a plateau. A field study was carried out on a loamy sand soil of Agra for two years (2008 to 2009) to study the effect of zinc with and without FYM on yield and uptake of sulphur in pearl millet-wheat cropping system. Nine different treatments of zinc doses with and without FYM were applied in the field having pearl millet and wheat cropping sequence to assess the uptake of sulphur and zinc. The changes in sulphur uptake brought about by combined use of FYM and Zn were pronounced and significant in the both years. Highest uptake of sulphur was recorded for the treatment giving higher grain and stover yields. The maximum values of Zn content in grain and stover were noted under 5 t FYM/ha + 10 kg Zn/ha in both crop seasons. When the combined effect of zinc and FYM was applied, an increase in zinc concentration was found significant in both crop seasons. The maximum values of zinc content in wheat grain and straw were recorded under 10 kg Zn/ha and 5 t FYM/ha treatment in both the years of study. The results emphasized the usefulness of integrated use of FYM and Zn on sulphur nutrition of the pearl millet-wheat sequences

Keywords: FYM, Sulphur, Zn, Nutrients, Millet, Wheat, Fertilizers

Introduction
The most fundamental function of sulphur in plant nutrition is that it aids in the biosynthesis of chlorophyll. As of today, sulphur has acquired the status of a strategic element in a balanced fertilization programme where it acts as important essential element as well as catalyst in improving the efficiencies and/or counteracting adverse effects of other elements The application of S up to 30 kg/ha enhanced the average grain yield of maize by 22 per cent over control. The application of Zn upto 5 kg/ha increased the maize yield by 19 per cent over control. On fitting the average grain yield data of two year in to quadratic equation, the optimum dose of sulphur for maize was found to be 34.3 kg/ha for the maximum grain yield of 22.7 g/ha. Similarly the optimum dose for zinc was found to be 7.1 kg /ha giving maximum yields of 29.8 q/ha. Similar trend in yield response of stover was also recorded (Dwivedi *et al*. 2002) [1].

Green fodder, dry matter and protein yield of oat improved significantly with increasing levels of zinc sulphate at 100% NPK. Zinc sulphate application also improved the uptake of NPK and Zn by oat crop (Verma *et al*. 2002) [11]. The residual effect of 2.5 ppm Zn was sufficient to obtain the highest grain yield of wheat after both the crops. The third crop of peal millet and cowpea responded significantly upto 20 and 40 ppm residual Zn levels, respectively (Gupta *et al*.1986) [2]. Application of 6 kg Zn /ha significantly increased all the growth and yield attributes (except test weight) protein content and Zn uptake by wheat over no use of Zn (control). Application of graded levels of zinc upto 9 kg Zn/ha remained at par with 12 kg Zn/ha significantly increased Zn uptake by wheat crop over other levels. Application of 6 kg Zn/ha increased in grain and straw yields by 19.4 and 16.8% over the no use of Zn (control). Application of 60 kg P_2O_5/ha and 6-9 kg Zn/ha to wheat significantly improved the growth and yield attributes (Jain and Dahama 2006) [3]. With loamy sand soil the application of 5 levels of Zn (0, 1.25, 2.50, 5.0, 10.0 ppm) significantly increased the average dry matter yield of maize shoot from 6.4 to 13.6 and Zn from 9.81 to 12.52 g/pot. The highest yield (14.95 g/pot) was recorded at 10 ppm S and 2.5 ppm Zn. Higher levels of both these nutrient produced low yield probably due to imbalanced nutrient (Kochar *et al*. 1990) [4].

Four kg Zn /ha produced highest seed yield of 19.81 q /ha which was 19.55 percent higher in comparison to lowest yield at control. The N, P, K, S, Zn glucosinolate and non-protein nitrogen contents in leaf and N, P, K, S and Zn uptake at maturity were significantly affected with P addition (Mishra *et al*. 2001) [6]. The application of zinc sulphate, FYM and Zn-enriched FYM to soils decreased the pH and increased the available Zn content of sodic-water-irrigated soils, whereas the application of FYM increased the EC and SARe of irrigated soils. The application of zinc sulphate with sodic water decreased the concentration of Na and enhanced the concentration of K, Ca and Zn in the shoot tissues of lemongrass as compared to sodic water alone (Prasad *et al*. 2010) [7]. Response of winter maize to Zn on 23 alluvial soils of semi-arid tropics in Punjab. Zinc addition to the soil significantly increased the dry matter production and Zn uptake by the crop (Sharma *et al*. 1990) [8]. Farmyard manure increased the crop growth as judged from dry matter. The N and P contents increased significantly with increasing levels of farmyard manure compared with the control (Singh *et al*. 1994) [9]. The uptake of N, P and S was significantly enhanced by applied P and S in both wheat and soybean crops. Phosphorus applied at 26.8 and 4.02 mg P/kg and applied at all levels increased the grain of soybean but Zn had no effect (Varavipour *et al*. 1999) [10].

Pearl millet-wheat sequence is predominant in north-western plain zone and central zone of India. 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. In sustainable crop production, organic manuring plays an important role. The results of a large number of experiments on manures and fertilizers conducted in the country and aboard reveal that neither the chemical fertilizer alone nor the organic sources exclusively can achieve the production sustainability of soils as well as crops under highly intensive cropping system. Therefore, it becomes necessary to know the suitable combination of zinc fertilizers with organic manures for profitable crop production in cereal based cropping system**.**

Material and Methods

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 to evaluate the effect of zinc with and without FYM yield and uptake of sulphur on pearl millet-wheat cropping system. The details of the materials used and procedures employed in the study are described in the following manner.

Geology and Climate

The area under investigation falls in the Indo-Gangetic plains. The soils in this tract owe their origin to the alluvium deposited by the two great 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 khaddar. The boundary between two alluviums is not sharp the old alluviums usually occupy terrace like position and tend to be silty sands.

The climate of Agra district on the whole is hot and dry. The mean annual rainfall for this district is around 65 cm of which nearly 90 per cent is received during the rainy season i.e. from June to September. However, a few showers commonly occur during winter season and sometimes fog and frost are also experienced. Desiccating winds and scorching heat characterize summers. The soils are of great depth and are not often fully mature in development and are essentially basic in character; usually light textured and highly productive.

Experimental site

The experiment was carried out in plot B-12b of the Raja Balwant Singh College, Research Farm, Bichpuri (Agra) during both the consecutive 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/has
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, diammonium 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. At the time of harvesting, 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 labeling. The following determinations were made from the well-prepared plant materials.

Sulphur
It was determined in acid extract by turbidimentric method (Chesnin and Yien, 1951).

Zinc
Zinc in the diacid (HNO_3 and $HClO_4$) extract of the plant material was determined on an atomic absorption spectrophotometer.

Uptake studies
The uptake of sulphur and zinc 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 zinc
The soil was shaken with a mixture of 0.005 M DTPA, 0.01 M $CaCl_2$ and 0.1 M triethanolamine (pH 7.3) as suggested by Lindsay and Norvell (1978). The aliquot was filtered through Whatmann No. 42 filter paper. The zinc contents in the prepared extract were determined in an atomic absorption spectrophotometer.

Statistical analysis
The data regarding yield, chemical composition and sulphur and zinc uptake were processed and analyzed 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

(A) Pearl millet
Content and Uptake of Sulphur: Data on sulphur content and uptake are presented in Fig 1&2. There was a significantly higher content of sulphur in pearl millet crop under all the treatment as compared to control. Sulphur content in grain and straw increased with zinc levels. FYM addition also improved the sulphur content in grain from 0.19 to 0.21 per cent and from 0.20 to 0.22 per cent, respectively during first and second year. Combined application of 5 t FYM/ha and zinc levels further improved the sulphur content in grain and straw over control and zinc alone in both crop seasons. Thus, the trend of results obtained in this study suggested a favourable effect of FYM on sulphur nutrient of wheat crop. The maximum percentage of sulphur in crop was recorded under 5 t FYM + 5 kg Zn/ha in both crop seasons. A further study of Fig 1&2 reveals that there was a gradual increase in sulphur uptake by the crop with increasing levels of Zn upto 7.5 kg Zn/ha. Thereafter, a reduction was noted with 10 kg Zn/ha over 7.5 kg Zn/ha treatments in both crop seasons. The higher values of sulphur uptake with lower levels of Zn could be attributes to enhanced grain and stover yield of pearl millet. The data indicate that application of FYM alone or in combination with Zn levels significantly increased the sulphur uptake in crop. The changes in sulphur uptake brought about by combined use of FYM and Zn were pronounced and significant in the both years. Highest uptake of sulphur was recorded for the treatment giving higher grain and stover yields.

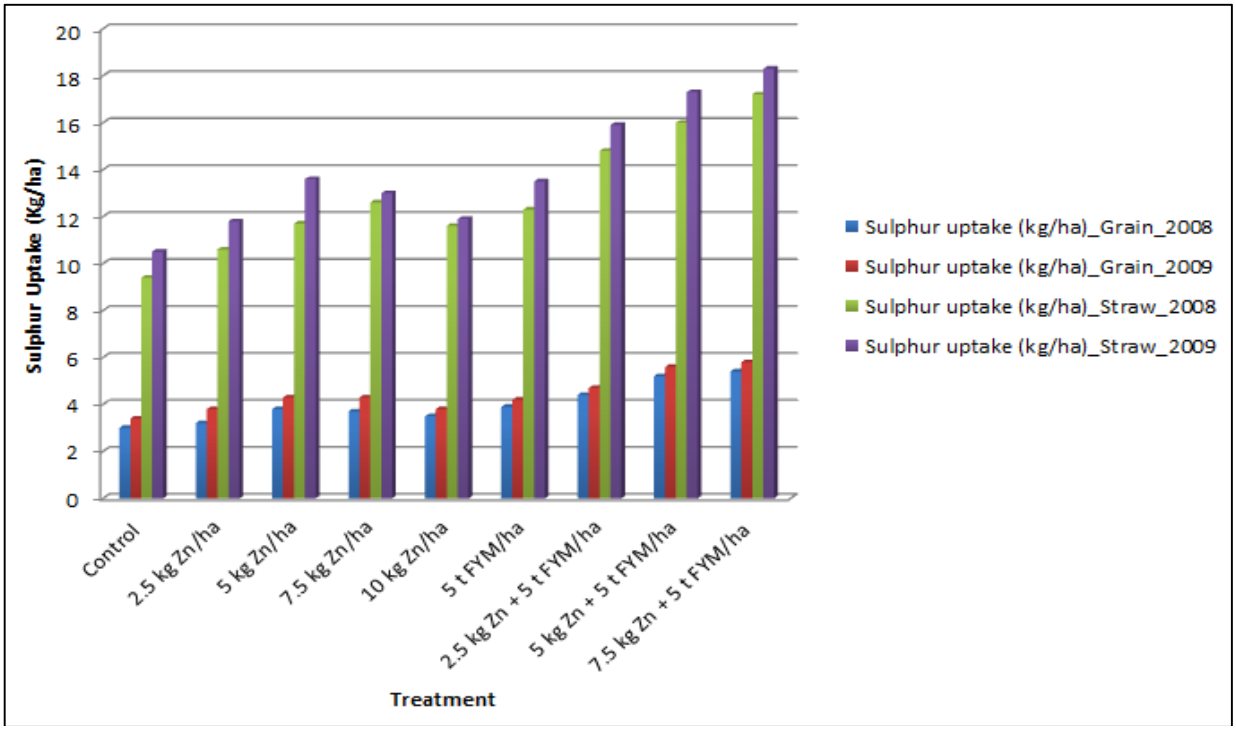

Fig 1: Effect of various treatments on uptake of sulphur by pearl millet grain and stover

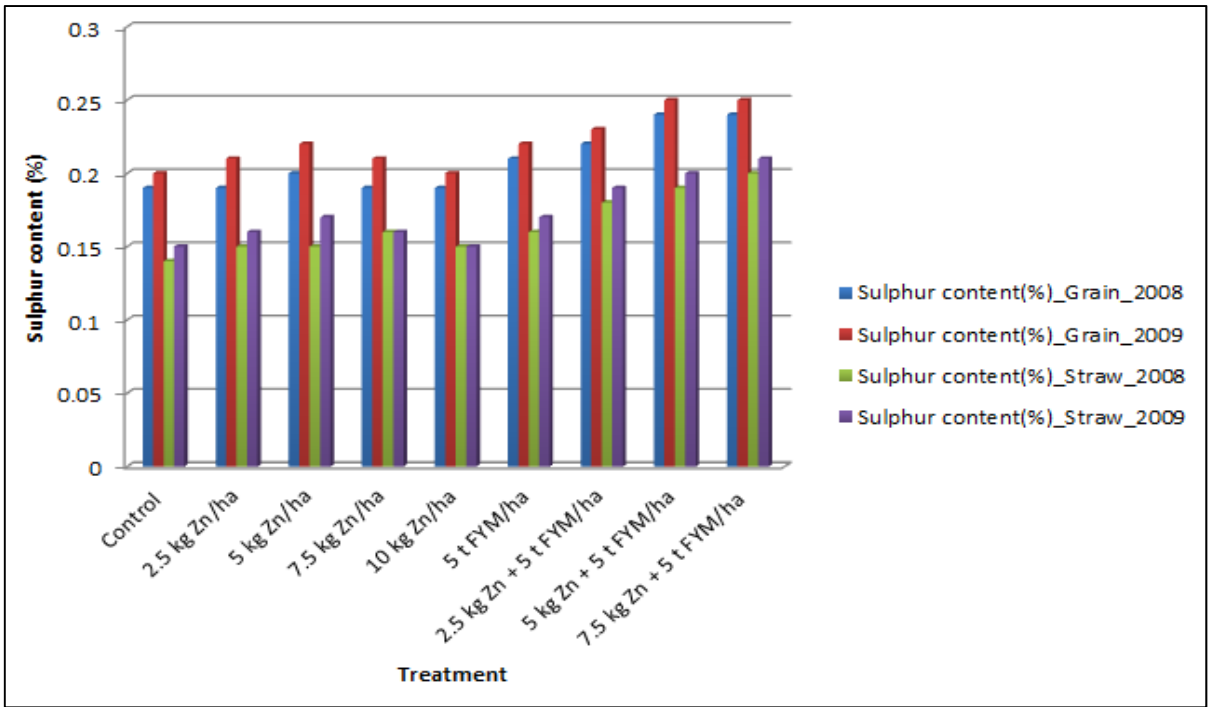

Fig 2: Effect of various treatments on content of sulphur by pearl millet grain and stover

Content and uptake of Zinc in pearl millet: Data on content and uptake of Zn by pearl millet crop are presented in Table 1. A study of the data reveals that the application of zinc increased its content in grain and stover significantly over control. This increase in zinc content in grain and stover may be attributed to increased availability of zinc as a result of its addition. Application of 5 t FYM/ha, also increased the content of zinc in pearl millet crop significantly over control in both crop seasons. The combined use of FYM and Zn resulted in higher value of Zn content in grain and stove. The maximum values of Zn content in grain and stover were noted under 5 t FYM/ha + 10 kg Zn/ha in both crop seasons. A perusal of the data (Table 1) indicates that the application of zinc increased its uptake significantly over control in both crop seasons. The higher values of Zn uptake were noted at 10 kg Zn/ha. The Zn uptake by grain increased from 35.8 to 63.1 g/ha and from 38.8 to 64.8 g/ha with 7.5 kg Zn/ha during first and second year, respectively. The corresponding increases by stover were from 203.9 to 315.8 and from 215.0 to 330.4 g/ha. Application of Zn and FYM, either alone or in combination significantly increased the zinc uptake by the crop. The zinc along with FYM was more effective than zinc application alone. This suggests that besides adding zinc to soil, FYM also enhanced the efficiency of applied zinc and solubilizes native Zn to make it available for plants

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

Treatment	Zn content(mg/kg)				Zn uptake (kg/ha)			
	Grain		Stover		Grain		Stover	
	2008	2009	2008	2009	2008	2009	2008	2009
Control	22.4	23.0	30.2	30.7	35.8	38.8	203.9	215.0
2.5 kg Zn/ha	26.0	26.6	33.4	34.0	44.8	48.0	237.3	250.9
5 kg Zn/ha	29.2	29.5	35.8	36.7	55.7	58.5	280.0	293.8
7.5 kg Zn/ha	32.0	32.7	39.5	40.4	662.7	66.7	312.6	327.8
10 kg Zn/ha	33.7	33.5	40.7	41.6	63.1	64.8	315.8	330.4
5 t FYM/ha	28.5	29.1	34.6	35.2	53.1	56.1	265.5	279.9
2.5 kg Zn + 5 t FYM/ha	29.8	30.2	36.0	36.7	59.7	62.7	296.0	308.2
5 kg Zn + 5 t FYM/ha	32.0	32.7	38.2	38.8	69.8	73.6	322.9	335.7
7.5 kg Zn + 5 t FYM/ha	33.4	33.6	40.0	41.0	75.6	78.0	344.3	357.6
SEm±	1.52	1.48	1.57	1.61	3.01	2.95	7.81	8.02
CD (P=0.05)	4.44	4.32	4.58	4.70	8.78	8.61	22.80	23.41

(B) Residual effect on wheat

Content and uptake of Sulphur in wheat: A perusal of the data (Table 2) shows that the different treatments had marked effect in comparison to control on content of sulphur in wheat crop during both the years. But the levels of Zn alone did not influence the sulphur content in wheat crop significantly over control. FYM application alone or in combination had significantly beneficial effect on absorption of sulphur in wheat crop. These treatments (T_6 and T_9) have reported to have significantly beneficial effect on sulphur content in wheat crop in both crop seasons. The results emphasized the usefulness of integrated use of FYM and Zn on sulphur nutrition of the crop. Application of 5 t FYM/ha along with 5 kg Zn/ha in preceding pearl millet crop had highest sulphur content in the crop. The treatment T_8 and T_9 were statistically at par with respect to sulphur content in wheat crop in both crops season.

Table 2: Residual effect of various treatments on sulphur content and uptake by wheat grain and straw

Treatment	Sulphur continent (%)				Sulphur uptake (kg/ha)			
	Grain		Straw		Grain		Straw	
	2008	2009	2008	2009	2008	2009	2008	2009
Control	0.21	0.22	0.15	0.16	9.4	10.0	8.4	9.1
2.5 kg Zn/ha	0.21	0.23	0.16	0.17	9.7	10.8	9.2	9.9
5 kg Zn/ha	0.22	0.24	0.16	0.18	10.5	11.8	9.7	11.1
7.5 kg Zn/ha	0.21	0.23	0.17	0.17	10.4	11.4	10.4	10.6
10 kg Zn/ha	0.21	0.22	0.16	0.16	10.3	10.8	9.7	9.9
5 t FYM/ha	0.23	0.24	0.17	0.18	11.1	11.8	10.4	11.2
2.5 kg Zn + 5t FYM/ha	0.25	0.25	0.19	0.20	12.5	12.8	12.0	12.9
5 kg Zn + 5 t FYM/ha	0.26	0.26	0.20	0.22	13.1	13.5	12.7	14.4
7.5 kg Zn + 5t FYM/ha	0.26	0.26	0.21	0.22	13.3	13.6	13.5	14.5
SEm	0.004	0.005	0.002	0.004	0.18	0.19	0.21	0.24
CD (P = 0.05)	0.011	0.014	0.008	0.011	0.52	0.55	0.61	0.70

A further study of Table 2, indicates that the uptake values of Sulphur by wheat crop commensurate with grain and straw yields during both the years. The sulphur uptake by the crop was not affected significantly with residual effect of Zn levels. However, the lower levels upto 5 kg Zn/ha slightly improved the utilization of zinc by wheat crop in both the years. The residual effect of FYM had significantly beneficial effect on the utilization of sulphur by wheat crop. The sulphur uptake by wheat crop was further improved with the combined use of FYM and Zn. Application of 5 t FYM/ha was more effective with higher zinc levels in enhancing the uptake of sulphur by wheat crop in both crop seasons.

Content and uptake of Zinc in wheat: A study of Fig 3&4 reveals that the zinc application in preceding crop increased the concentration of Zn in wheat grain and straw significantly over control. The zinc content in wheat grain during first and second year increased from 19.8 to 29.5 mg/kg and 20.2 to 30.0 mg/kg with 10 kg Zn/ha, respectively. This increase in zinc content in plants may be ascribed to increased availability of zinc in soil on the addition of soluble $ZnSO_4$. Dwivedi *et al.* (2004) also reported similar results. Application of 5 t FYM/ha in preceding pearl millet crop improved the absorption of zinc by the crop over control.

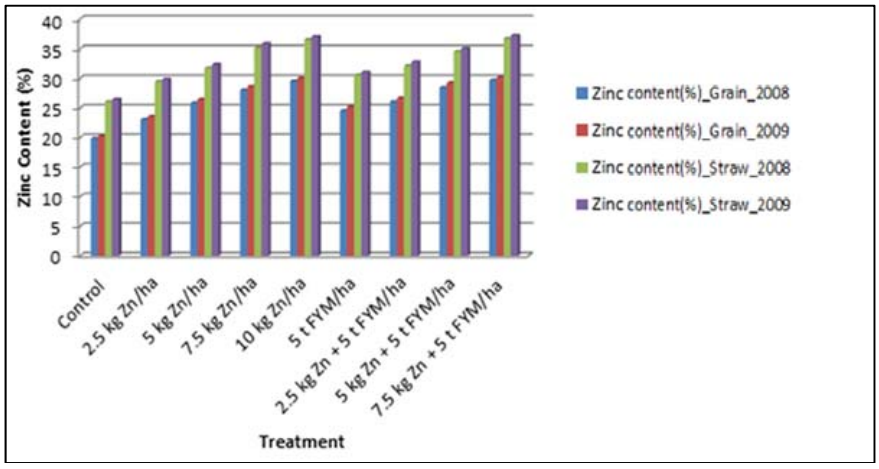

Fig 3: Residual effect of various treatments on zinc content by wheat grain and straw

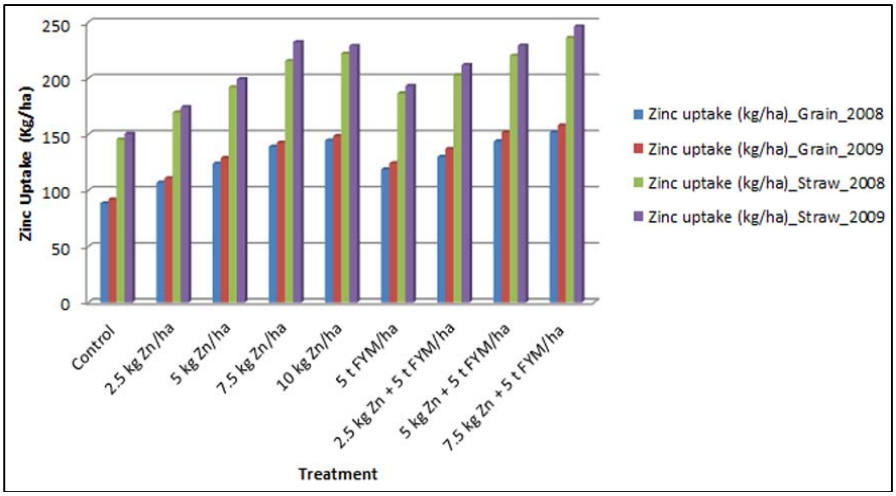

Fig 4: Residual effect of various treatments on zinc uptake by wheat grain and straw

A further study of above Fig 3 & 4 indicates that the application of zinc in preceding crop significantly increased the average zinc uptake by wheat grain from 90.2 to 146.5 g/ha. Each level of applied zinc had significantly beneficial effect on its uptake by wheat crop. This increase in Zn uptake with its addition may be ascribed to greater grain and straw production. The residual effect of FYM on zinc uptake by wheat grain and straw was significant over control in both crop seasons. The maximum values of zinc uptake by wheat grain and straw were recorded under 10 kg Zn/ha and 5 t FYM/ha treatment in both crop seasons. The results, thus, indicate the beneficial effect of combined used of Zn levels with FYM.

Conclusion

In the light of the results summarized above it may be concluded that the direct applications of zinc and its residual amount improved the yields of pearl millet and wheat uptake of nutrients available sulphur and zinc in soil after harvest of these crops. It appears that soil applications of zinc to pearl millet has good residual effect and need of sulphur and zinc for wheat can be met from the applications of pearl millet in a pearl millet-wheat rotation. Through zinc fertilizer alone, its superiority with respect to yield of pearl millet and wheat crop from soil fertility sustainability point of view integrated use of zinc and FYM performed better than application of zinc alone.

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