ISSN 2277-9663

AGRES - An International e-Journal

Volume 1 Issue 1 January-March,2012

EFFECT OF SULPHUR AND ZINC ON YIELD, QUALITY AND ECONOMICS OF MUSTARD AND POST HARVEST AVAILABILITY OF NUTRIENTS IN SOIL

JAT, J.S.*; RATHORE, B.S. AND CHAUDHARY, M.G.

Department of Agricultural Chemistry and Soil Science
Rajasthan College of Agriculture
Udaipur - 313 001, Rajasthan

E.mail. jsjatagchem@gmail.com

ABSTRACT

A Field experiment was conducted for two years (i.e. 2001-02 and 2002-03) with mustard [Brassic juncea (L.) Czern and Coss.] as a test crop on clay loam soil with five doses of sulphur (i.e., 0, 20, 40, 60 and 80 kg S ha^{-1}) and zinc (i.e., 0, 2.5, 5.0, 7.5 and 10.0 kg Zn ha^{-1}). Application of 40 kg S ha^{-1} and 5.0 kg Zn ha^{-1} significantly increased seed yield, oil content, oil yield and net returns of crop during both the years of experimentation. Protein content and B: C ratio upgraded significantly only upto 20 kg S ha^{-1} and zinc upto 2.5 kg ha^{-1} significantly increased protein content. Organic carbon content, phosphorus, sulphur and micronutrients content of soil increased significantly with increasing rates of sulphur upto 80 kg S ha^{-1} except at 0 to 20 kg S ha^{-1}. With increasing rates of zinc upto 5.0 kg ha^{-1} significantly increased the organic carbon and zinc upto 10 kg ha^{-1} except 0 – 2.5 kg Zn ha^{-1} application. The economic optimum requirement of sulphur and zinc for the seed yield of mustard was 68.87, 62.98 kg S ha^{-1} and 6.40, 6.55 kg Zn ha^{-1} for the respective years, respectively.

KEY WORDS: Sulphur, Zinc, Mustard, Yield, Quality, Economics

INTRODUCTION

The declined soil fertility is the main cause of low productivity of the cultivated lands. So the emphasis has been to supplement the soil with the major nutrients, viz., N, P and K and the crop requirements for secondary and micronutrients could be met with soil reserves. According to soil test analysis use of high analysis fertilizers, limited recycling of plant residues and gap between the removal and supplementation of secondary and micronutrients have resulted in widespread multiple nutrients deficiencies specially for N, P, K, S and Zn along with other nutrients. Singh and Singh (1981) reported that most of the soils of Rajasthan were deficient in zinc and assigned the low availability of zinc to alkaline reaction, low organic carbon and high $CaCO_3$ content. The utilization of fertilizer zinc seldom exceeds 2% (Sharma *et al*., 1990) with large portion of added zinc remaining unutilized. Therefore, the present investigation was carried out to study the effect of sulphur and zinc application on yield, quality, economics and post harvest availability of nutrients of mustard.

MATERIALS AND METHODS

A field experiment was conducted during the winter (rabi) seasons of 2001-02 and 2002-03 at Udaipur on clay loam soil. The soil has pH 8.42 and 8.26, EC 0.86 and 0.69 dsm^{-1}, 6.4 and 7.1 g kg^{-1} organic carbon, 280.7 and 292.4 kg ha^{-1} available nitrogen, 22.6 and 21.2 kg ha^{-1} available phosphorus, 365.5 and 370.7 kg ha^{-1} available potassium, 9.4 and 10.2 mg kg^{-1} available sulphur, 0.60 and 0.64 mg kg^{-1} DTPA extractable zinc, 4.20 and 4.42 mg kg^{-1} DTPA Fe, 9.4 and 10.6 mg kg^{-1} DTPA Mn, and 0.65 and 0.69 mg kg^{-1} DTPA Cu during 2001-02 and 2002-03 ,respectively. The treatments consisting of 5 sulphur levels (0, 20, 40, 60 and 80 kg ha^{-1}) in main plot and 5 levels of zinc (0, 2.5, 5.0, 7.5 and 10.0 kg ha^{-1}) in sub-plot were laid out in split plot design with four replications. Treatments were applied as basal dressing through gypsum and zinc chloride as per treatments. Uniform application of 60 kg nitrogen (half at the time of sowing and half at 35 days of sowing) through urea and DAP and 40 kg phosphorus through DAP at the time of sowing were made. Mustard variety "Pusabold" was sown in rows at 30 cm apart using 5 kg seed ha^{-1} on 3 November in 2001 and 29 October in 2002 and harvested 120 days after sowing. Soil samples were drawn from each experimental plot upto 15 cm depth with the help of screw auger in zig-zag pattern from four

ISSN 2277-9663

AGRES – An International e-Journal

Volume 1 Issue 1 January-March,2012

points in each plot after the harvest of mustard crop. Samples after preparation were used for analysis of organic carbon by Walkeley and Black (1947) rapid titration method, available nitrogen by Subbiah and Asija (1956) alkaline $KmnO_4$ method, available phosphorus by Olsen *et al.* (1954) method, available potassium by Richards (1954) neutral normal ammonium acetate method, available sulphur by Williams and Steinberg (1954) 0.15% $CaCl_2$ extraction method. DTPA extractable Zn, Fe, Cu and Mn in soil were determined by atomic absorption spectrophotometer as described by Lindsay and Norvell (1978). Protein content was obtained by multiplying total N-content with 6.25. Oil content was extracted with petroleum ether and estimated by soxhlet's method.

RESULTS AND DISCUSSION

(A)Seed yield, Oil content, Protein content and Oil yield

A perusal of data (Table – 1) revealed that across the years of experimentation a significant increase in seed yield, oil content and oil yield of mustard upto 40 kg S ha^{-1}, which was at par with 60 and 80 kg S ha^{-1} application. The seed yield, oil content and oil yield increased by 24.80 percent in 2001-02 and 24.81 percent in 2002-03 over no sulphur, respectively. The protein content was upgraded significantly only upto 20 kg S ha^{-1} application, Seed yield enhanced with increasing supply of sulphur because it helps in the process of tissue differentiation from somatic to reproductive, meristemaric activity and increase in the development of floral primordia, resulting in more flowers and siliqua, longer siliqua resulting in robust siliqua and better seeds. The sum total effect will be higher seed yield (Singh and Verma 1989). Oil content increased significantly due to sulphur being an integral part of mustard oil. Thus, sulphur supply seems to be involved in increased conversion of primary fatty acids metabolites to end product of fatty acids. Moreover, several enzymes catalysing essential metabolic processes including biosynthesis of lipids are known to contain sulphur containing amino acids in their structure. A significant increase in oil yield seems owing to be cumulative effect of increased oil content and seed yield in response to sulphur application. The results are in line with the findings of Dubey *et al.* (1994) and Kuhurana *et al.*(1998). Significant increment in protein content might be due the fact that sulphur is a constituent of some amino-acid present in protein. Further, it also participates in several bio-chemical reactions. The reserve is in cognizance with the findings of Dewal *et al.* (2001).

A critical examination of data in Table – 1 show that the maximum seed yield, oil content in seed and oil yield was increased up to the level of 7.5 kg Zn ha^{-1} but the significant increment was observed only upto 5.0 kg Zn ha^{-1} application. Application of 5.0 kg Zn ha^{-1} increased seed yield and oil yield by 18.25 and 21.02 percent in 2001-02 and 18.19 and 20.19 percent in 2002-03 over control, respectively. Protein content increased significantly only upto 2.5 kg Zn ha^{-1} application. The increase in yield might be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiation of primordia for reproductive parts and partitioning of photosynthates towards them, which resulted in better flowering and fruiting (Shamra *et al.*; 2000). Zinc functions in plant largely as a metal activator of enzymes like cysteine desulphydrase, dihydropeptidase, glycylglycine dipeptidase etc. (Tisdale and Nelson, 1970), which results in increase in oil content. Thus, addition of zinc might have activated the enzymes responsible for the production of oil and caused higher oil contents. A significant increase in oil yield seems owing to the increase in oil content and seed yield. The results are closely conformity with the findings of Misra (2001). The magnificent role of zinc in increasing the metabolic and physiological activity of the plants is of paramount importance as it influenced the nitrogen matabolism, chlorophyll formation, cell division, protein synthesis and auxin concentration, which is responsible for higher protein content of mustard seed. The results are closely conformity with the findings of Malakouti (1998).

Economics

Net return and B : C ratio

A perusal of data presented in Table – 2 reveal that maximum net return and B : C ratio was recorded under 60 kg S ha^{-1} application, though which was at par with 40 and 80 kg S ha^{-1} during both the years of experimentation. Net return upgraded significantly up to 40 kg S ha^{-1} but increase in B : C ratio was recorded only upto 20 kg ha^{-1}. The corresponding increase in net profit and B : C ratio were 44.98, 33.16 percent during 2001-02 and 41.92, 30.12 percent during 2002-03, respectively over control with the application of 60 kg S ha^{-1}.

ISSN 2277-9663
AGRES – An International e-Journal
Volume 1 Issue 1 January-March,2012

The data presented in above table explicit that net return increased with increasing level of zinc upto 7.5 kg ha^{-1} but B: C ratio increased upto 5 kg Zn ha^{-1}. Beyond 5 kg Zn ha^{-1} net return (Rs ha^{-1}) and B: C ratio decreased. Net return upgraded significantly upto 5.0 kg Zn ha^{-1}, In case of B: C ratio 5 kg Zn ha^{-1} increased significantly more over control.

Economic optimum dose

The optimum requirement of sulphur for maximum economic seed yield of mustard was worked out with the help of response equation. It is apparent from the Table – 3 that the maximum seed yield of 21.49 q ha^{-1} and 22.16 q ha^{-1} could be obtained with the application of optimum doses of 68.87 kg S ha^{-1} and 62.98 kg S ha^{-1} during 2001-02 and 2002-03, respectively.

Further data reveal that maximum optimum yield 20.70 q ha^{-1} and 21.58 q ha^{-1} was obtained with the application of economic optimum doses i.e. 6.40 kg Zn ha^{-1} and 6.55 kg Zn ha^{-1} during 2001-02 and 2002-03, respectively.

Organic carbon and available macronutrients (N, P, K and S)

Organic carbon content of soil increased with increasing levels of sulphur upto 80 kg S ha^{-1} but the significant increase was recorded only upto 40 kg S ha^{-1} in the year of 2001-02 but upto 60 kg S ha^{-1} in the year of 2002-03 (Table 4). Application of sulphur upto 80 kg S ha^{-1} significantly increase in available phosphorus and sulphur content of soil after harvest of mustard except at 0 to 20 kg S ha^{-1} but in the year of 2002-03 significant build up in sulphur content was noted above 40 kg S ha^{-1} application. Nitrogen and potassium content in soil did not affected significantly with the application of sulphur (Table 4). The significant increase in organic carbon content of soil after harvest of mustard crop may be attributed to the addition of organic matter to the soil by the extensive root system which remains in the soil after harvest of crop. Similar findings were recorded found by Patel (1992). Application of sulphur has been reported to help in lowering the soil pH which is the principal reason for greater availability and mobility of native nutrients (Patel and Patel 1985). The higher sulphur content in soil could also be attributed to a greater mineralization of organic-S and release of SO_4^- ions on its gradual oxidation. The addition of sulphur which is not absorbed by plants also increases the residual sulphur content of soil. Similar findings were observed by Akbari *et al.* (1999).

Organic carbon content increased significantly with increasing levels of zinc upto 5.0 kg ha^{-1} (Table 4). The beneficial role of zinc in increasing the cation exchange capacity of roots helped in increased absorption of nutrient from the soil. This resulted in an increase in root and shoot weight of plant causes more addition of organic matter to the soil. (Sharma *et al.* 1990). Application of zinc did not effect significantly nitrogen, phosphorus, potassium and sulphur content of soil after harvest of mustard (Table 4) but marginal reduction in phosphorus content due to antagonistic effect of zinc and phosphorus content at higher levels (10 kg Zn ha^{-1}) due to the formation of some unavailable or less available compound like zinc phosphate. The results are closely related with findings of Rajput (1997).

Micronutrient content (Zn, Fe, Mn and Cu)

A critical examination of data (Table 5) reveal that post harvest available micronutrients (Zn, Fe, Mn and Cu) increased significantly with increasing levels of sulphur upto 80 kg S ha^{-1} except at lower level i.e. 0 to 20 kg ha^{-1}. The increase in availability of micronutrients with sulphur application might be due to decrease in pH, higher rate of mineralization of native nutrients, favourable condition for microbial and chemical activity, improved physicochemical properties of soil ameliorative effect of sulphur and better growth of roots resulting in higher nutrient absorption. These results are also supported by Ram *et al.* (1998).

Application of zinc did not significantly effect on post harvest availability of micronutrients (Fe, Mn anc Cu) except available zinc in soil. The availability of zinc in soil after harvest was increased significantly with increasing levels of zinc upto 10 kg ha^{-1} except 0 to 2.5 kg Zn ha^{-1} application. The significant increase in available zinc content in soil after harvest of mustard crop was due to comparatively lesser removed of this nutrient by crop compared to its addition which was expected to buildup the residual zinc content of soil. Nayak *et al.* (1997) has also reported similar findings.

REFERENCES

Akbari, K. N., Karan, F., Qureshi, F. M. and Pandya, H. R. (1999). Effect of micronutrients, sulphur and gypsum on yield of wheat and post harvest soil fertility in red loam soils of Mewar (Rajasthan). *Indian Journal of Agricultural Research* **33,** 80-86.

Dewal, G. S., Sharma, H. S. and Bareth, V. S. (2001). Effect of sulphur and FYM on yield and quality of barley (*Hordeum vulgare*). *Agronomy Digest* **1,** 42-44.

Lindsay, W.L. and Norvell, W.A. (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of American Journal* **42,** 421-428.

Malakouti, M. J. (1998). Increasing grain yield and community's health through the use of $ZnSO_4$ in wheat fields. *Soil and Water Journal* **12,** 34-43.

Misra, S. K. (2001). Effect of sulphur and zinc on yield, uptake of nutrients and quality of mustard. *Annals of Plant and Soil Research* **3,** 206-213.

Nayak, R., Chauhan, R. P. S. and Singh, G. (1997). Effect of N and Zn on wheat (*Triticum aestivum*) yield and nutrient uptake under partially reclaimed sodic soil. *Indian Journal of Agronomy* **42,** 293-296.

Olsen, S. R., Cole, C. V., Watanable, F. S. and Dean, L. A. (1954). Estimation of available phosphorus in soil by extraction with sodium carbonate. *Cir. USDA.,* 939.

Patel, B.A. (1992). Studies on sulphur and Zn fertilization with respect to yield, nutrient uptake and quality of mustard (*Brassica juncea* L.) in loamy sand. Doctoral Thesis, R.A.U., Bikaner.

Patel, M. S. and Patel, J. J. (1985). Effect of different levels of lime, sulphur, iron and mixture on yield and nutrient absorption by groundnut. *Indian Journal of Agricultural Research* **19,** 124-130.

Rajput, A. L. (1997). Effect of N and Zn split application on wheat and their residual effect on rice (*Oryza sativa*). *Indian Journal of Agronomy* **42,** 22-25.

Ram, H., Jha, C. K. and Prasad, J. (1998). Effect of sulphur and Rhizobium on soil pH, available N and P in green gram. *Fertilizer News* **43,** 51-53.

Richards, L. A. (1954). Diagnosis and improvement of saline and alkali soils. *U.S.D.A.,* Hand Book No. 60, Washington, D.C.

Sharma, P. K., Yadav, G. L., Sharma, B. L. and Kumar, S. (2000). Response of wheat (*T. aestivum*) to nitrogen and zinc fertilization. *Indian Journal of Agronomy* **45,** 124-127.

Sharma, U.C., Gangwar, M.S. and Srivastava, P.C. (1990). Effect of zinc and sulphur on nutrient uptake and yield of mustard. *Journal of the Indian Society Soil Science* **38,** 696-701.

Singh, M. and Singh, K. S. (1981). Zinc and copper status of soils of Rajasthan. *Annals of Arid Zone* **20,** 77-80.

Singh, S. B. and Verma, K. P. (1989). Studies of N application in potato-mustard intercropping system. *Indian Journal of Agronomy,* **34,** 413-6.

Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for the estimation of available nitrogen in soils. *Current Science* **25,** 259-260.

Tisdale, S. L. and Nelson, W. L. (1970). Soil fertility and fertilizers, 2nd ed. The Macmillan Co. Ltd., London, pp. 100.

Walkley, A. and Black, I. A. (1947). Rapid titration method for organic carbon of soils. *Soil Science* **37,** 29-32

Williams, C. H. and Steinbergs, A. (1959). Soil sulphur fraction as chemical index of available sulphur in some Australian soils. *Australian Journal of Agriculture Science Research* **10,** 340-353.

ISSN 2277-9663
AGRES - An International e-Journal

Volume 1 Issue 1 January-March,2012

Table 1: Effect of sulphur and zinc levels on seed yield, oil and protein content and oil yield of mustard

Treatments	Seed yield (q ha^{-1})		Oil content in seed (%)		Protein content in seed (%)		Oil yield (kg ha^{-1})	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Sulphur (kg ha^{-1})								
0	16.25	17.05	38.79	38.83	18.37	18.55	630.10	661.60
20	18.54	19.36	40.55	40.72	19.34	19.55	751.60	789.00
40	20.30	21.28	41.86	41.96	19.81	19.91	852.00	893.40
60	21.60	22.54	41.91	41.98	19.96	20.17	904.90	948.20
80	21.31	21.85	41.82	41.90	19.84	19.94	891.60	915.00
SEm±	0.48	0.59	0.42	0.40	0.20	0.18	20.70	26.20
CD at 5%	1.49	1.81	1.29	1.22	0.61	0.55	63.80	80.80
Zinc (kg ha^{-1})								
0.0	17.36	18.09	40.24	40.42	18.81	18.98	700.90	734.50
2.5	19.10	19.84	41.12	41.18	19.40	19.57	787.50	818.00
5.0	20.51	21.38	41.19	41.23	19.63	19.79	848.20	882.80
7.5	20.78	21.67	41.20	41.29	19.80	19.95	857.60	898.90
10.0	20.24	21.11	41.17	41.25	19.68	19.82	836.00	873.00
SEm±	0.46	0.49	0.35	0.32	0.16	0.15	20.70	21.80
CD at 5%	1.32	1.39	NS	NS	0.46	0.44	58.50	61.80

ISSN 2277-9663

AGRES - An International e-Journal

Volume 1 Issue 1 January-March,2012

Table 2: Effect of sulphur and zinc levels on net return and B : C ratio of mustard

Treatments	Net returns (Rs ha^{-1})		B : C ratio	
	2001-02	2002-03	2001-02	2002-03
Sulphur (kg ha^{-1})				
0	14900.40	17670.00	2.02	2.39
20	17819.30	20840.90	2.35	2.73
40	20032.30	23424.70	2.57	2.98
60	21602.80	25078.70	2.69	3.11
80	20951.40	23855.20	2.54	2.88
SEm±	632.60	823.30	0.08	0.10
CD at 5%	1949.20	2536.80	0.25	0.32
Zinc (kg ha^{-1})				
0.0	16744.80	19508.90	2.36	2.74
2.5	18757.10	21695.90	2.51	2.89
5.0	20294.80	23571.60	2.59	2.99
7.5	20310.20	23648.90	2.47	2.87
10.0	19199.30	22444.30	2.23	2.60
SEm±	529.50	634.70	0.08	0.09
CD at 5%	1497.90	1795.60	0.21	0.25

ISSN 2277-9663

AGRES – An International e-Journal

Volume 1 Issue 1 January-March,2012

Table 3: Optimum dose of sulphur and zinc for maximum economic yield of mustard

SULPHUR	ZINC
2001-02 $y = 16.1611 + 0.1462\,x - 0.001\,x^2$ $R^2 = 0.9933$ Price of sulphur = Rs. 11 kg^{-1} sulphur Price of produce = Rs. 1300 q^{-1} Economic optimum dose = 68.87 kg ha^{-1} Optimum yield = 21.49 q ha^{-1} Additional yield response kg kg^{-1} sulphur = 7.60 Additional return Rs Rs^{-1} on sulphur = 8.99	2001-02 $y = 17.2957 + 0.9490\,x - 0.0651\,x^2$ $R^2 = 0.9947$ Price of zinc = Rs. 100 kg^{-1} zinc Price of produce = Rs. 1300 q^{-1} Economic optimum dose = 6.40 kg ha^{-1} Optimum yield = 20.70 q ha^{-1} Additional yield response kg kg^{-1} zinc = 52.21 Additional return Rs Rs^{-1} on zinc = 4.53
2002-03 $y = 16.9086 + 0.1590\,x - 0.0012\,x^2$ $R^2 = 0.9869$ Price of sulphur = Rs. 11 kg^{-1} sulphur Price of produce = Rs. 1400 q^{-1} Economic optimum dose = 62.98 kg ha^{-1} Optimum yield = 22.16 q ha^{-1} Additional yield response kg kg^{-1} sulphur = 8.12 Additional return Rs Rs^{-1} on sulphur = 10.33	2002-03 $y = 18.0054 + 0.9857\,x - 0.0671\,x^2$ $R^2 = 0.9919$ Price of zinc = Rs. 100 kg^{-1} zinc Price of produce = Rs. 1400 q^{-1} Economic optimum dose = 6.55 kg ha^{-1} Optimum yield = 21.58 q ha^{-1} Additional yield response kg kg^{-1} zinc = 53.35 Additional return Rs Rs^{-1} on zinc = 4.98

x = optimum requirement of sulphur and zinc kg ha^{-1}

y = maximum economic grain yield q ha^{-1}

ISSN 2277-9663
AGRES – An International e-Journal

Volume 1 Issue 1 January-March,2012

Table 4: Effect of sulphur and zinc levels on organic carbon, available nitrogen, phosphorus, potassium and sulphur status in soil after harvest of mustard

Treatments	Organic carbon(g kg^{-1})		Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})		Available S (mg kg^{-1})	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Sulphur (kg ha^{-1})										
0	6.00	6.20	253.03	256.89	19.43	18.83	336.60	348.15	8.65	9.54
20	6.50	6.65	248.75	254.82	19.91	19.29	333.68	344.46	8.76	9.79
40	6.85	7.13	245.65	251.71	20.47	19.86	328.63	340.26	9.06	10.07
60	7.17	7.32	244.02	250.84	21.06	20.46	333.97	345.32	9.37	10.36
80	7.28	7.41	242.95	248.95	21.67	21.10	333.28	345.35	9.69	10.67
SEm±	0.07	0.07	2.62	2.63	0.17	0.18	3.04	3.68	0.09	0.10
CD at 5%	0.22	0.23	NS	NS	0.52	0.57	NS	NS	0.28	0.30
Zinc (kg ha^{-1})										
0.0	6.37	6.51	246.96	252.56	20.50	19.91	332.94	343.82	9.16	10.00
2.5	6.64	6.81	247.22	252.44	20.59	19.97	333.12	344.59	9.14	10.13
5.0	6.87	7.05	246.88	252.72	20.53	19.98	333.39	345.32	9.14	10.09
7.5	6.95	7.13	246.78	253.09	20.49	19.84	333.37	344.91	9.02	10.18
10.0	6.97	7.19	246.57	252.40	20.42	19.84	333.33	344.89	9.07	10.02
SEm±	0.07	0.06	2.47	1.97	0.14	0.16	2.90	2.62	0.08	0.08
CD at 5%	0. 19	0. 18	NS	NS	NS	NS	NS	NS	NS	NS

ISSN 2277-9663
AGRES - An International e-Journal

Volume 1 Issue 1 January-March,2012

Table 5: Effect of sulphur and zinc levels on available zinc, iron, manganese and copper content in soil after harvest of mustard

Treatments	Available zinc (mg kg^{-1})		Available iron (mg kg^{-1})		Available manganese (mgkg^{-1})		Available copper (mg kg^{-1})	
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03
Sulphur (kg ha^{-1})								
0	0.517	0.535	3.669	3.706	8.846	9.514	0.592	0.642
20	0.529	0.539	3.682	3.771	8.873	9.544	0.596	0.649
40	0.546	0.557	3.792	3.880	9.163	9.814	0.614	0.670
60	0.565	0.576	3.902	3.991	9.464	10.106	0.633	0.692
80	0.581	0.593	4.012	4.100	9.753	10.400	0.651	0.712
SEm±	0.005	0.005	0.034	0.035	0.091	0.081	0.005	0.006
CD at 5%	0.015	0.016	0.105	0.107	0.280	0.250	0.016	0.019
Zinc (kg ha^{-1})								
0.0	0.524	0.538	3.796	3.858	9.211	9.818	0.615	0.672
2.5	0.528	0.543	3.802	3.923	9.233	9.899	0.615	0.678
5.0	0.542	0.556	3.847	3.914	9.181	9.865	0.618	0.665
7.5	0.560	0.572	3.824	3.837	9.270	9.901	0.621	0.678
10.0	0.584	0.590	3.788	3.916	9.205	9.896	0.616	0.672
SEm±	0.005	0.004	0.031	0.027	0.082	0.077	0.005	0.005
CD at 5%	0.013	0.012	NS	NS	NS	NS	NS	NS