

Effect of zinc and farmyard manure on productivity and profitability of rice (*Oryza sativa*) - linseed (*Linum usitatissimum*) crop sequence

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Received: July 2008

ABSTRACT

A field experiment on rice (*Oryza sativa* L.) - linseed (*Linum usitatissimum* L.) crop sequence with 8 treatments was conducted for 3 consecutive years in silty loam soil having 0.85 ppm Zn between 2002-03 and 2004-05 at Kanpur. Application of zinc (through zinc sulphate @ 25 kg/ha) and farmyard manure (FYM) @ 5 t/ha to rice in rice-linseed crop sequence recorded maximum linseed equivalent yield (2.71 t/ha) and net monetary return (Rs 17,419/ha) which were on par with Zn in both the crops + FYM in rice and Zn in linseed + FYM in rice. Like linseed equivalent yield (LEY), oil yield of linseed (mean of 3 years) was also recorded higher with treatment of Zn in both the crops + FYM while other treatments of FYM followed it closely. Application of Zn alone irrespective of crop season also brought numerical increase in the yield of rice and linseed, LEY and NMR over recommended dose of fertilizer (RDF). However, net monetary return (NMR) recorded was higher when Zn was applied to rice alone when compared with Zn application in rice and linseed as well as linseed alone. The uptake of zinc was recorded maximum when it was applied to both crops either with or without FYM @ 5 tonne/ha than single crop alone. The nutrient status of the soil after the harvest of third crop of linseed was better when both Zn and FYM were applied to rice crop. Thus, it would be better to apply Zn (through zinc sulphate @ 25 kg/ha) and FYM @ 5 t/ha to rice in rice - linseed crop sequence for higher productivity and profitability of the system along with enriched soil as well as good oil yield from linseed.

Key words: Integrated nutrient management, Linseed, Zinc, Rice, Sequential cropping

Linseed (*Linum usitatissimum* L.) crop can be sown successfully upto 15 November in double cropping system with an acceptable loss in yield (Dixit *et al.*, 1994) and thus may be fitted well in the rotation after medium duration rice (*Oryza sativa* L.). The extent of zinc deficiency varied from 60 to 68% in the soils of Uttar Pradesh (Takkar and Nayyar, 1984) and linseed crop is sensitive to zinc deficiency that causes *khaira* disease in rice. Like major plant nutrients, zinc deficiency in soil may be the key factor for poor yield. FYM improves the soil properties and finally crop yield (Bhatia and Shukla, 1982). The present field study was undertaken to find out the effect of zinc and FYM in rice - linseed crop sequence.

MATERIALS AND METHODS

A field experiment was conducted for 3 consecutive years between 2002-03 and 2004-05 at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur at fixed site. The experimental soil was silty loam in texture, low in organic carbon (0.39%); medium in available

phosphorous (20 kg/ha) and potassium (240 kg/ha) and above critical limit in Zn (0.85 ppm) with slightly alkaline reaction (pH 7.8) initially. The experiment consisting 8 treatments was laid out in randomized block design with 3 replications. Three schedules of Zn application were tested in the absence and presence of FYM in rice-linseed crop sequence (Table 1) and compared with recommended dose of fertilizer application (RDF) as well as absolute control. Zinc through zinc sulphate @ 25 kg/ha and FYM @ 5 t/ha were also applied as per treatment. The nutrient composition (NPK%) of FYM was 0.50 (N), 0.25 (P), 0.40 (K) and 31 ppm Zn during 2002-03; 0.56 (N), 0.30 (P), 0.45 (K) and 33 ppm Zn during 2003-04; 0.54 (N), 0.28 (P), 0.44 (K) and 32 ppm Zn during 2004-05. Thus FYM added 21.25 kg N, 10.63 kg P, 17 kg K and 0.132 kg Zn during 2002-03; 23.80 kg N, 12.75 kg P, 19.13 kg K and 0.140 kg Zn during 2003-04; 22.95 kg N, 11.90 kg P, 18.7 kg K and 0.136 kg Zn during 2004-05 ha. The rice crop 'Pant -4' was transplanted at a spacing of 20 cm x 10 cm during first week of July while linseed crop 'Shekhar' was sown in lines 25 cm apart during second week of November after the harvest of rice crop dur-

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ing third week of October followed by pre-sowing irrigation. The linseed crop was harvested during second week of April every year. Rice and linseed received a RDF of 120-26.4-50 and 80-17.6-25 kg N-P-K/ha respectively every year. Oil-content of linseed was estimated with the help of NMR (Oxford model : MQA 7005) while oil yield was calculated by multiplying seed yield with oil content. Cost of cultivation and net monetary returns were based on prevailing market price of inputs (labour : Rs 58/labour/day, bullock: Rs 150/ pair of bullocks/day, seed cost : Rs 30/kg , average cost of N, P, K, ZnSO₄ (Rs/kg): 9.80, 36.32, 8.00 and 25.00) and produce (rice grain : Rs 5,500/t and linseed seed : Rs 16,000/t). The straw yield of linseed was not taken into account for the purpose, because it has no economic value in this area, whereas, B: C ratio was calculated by dividing net monetary return with cost of cultivation.

RESULTS AND DISCUSSION

Grain yield of rice

The yield of rice increased significantly under all the treatments over control during all the years of experimentation as well as on pooled basis (Table 1). Grain yield of rice recorded in 2002-03 and 2003-04 was significantly higher when Zn and FYM both were applied in rice but Zn in both the crops and FYM in rice excelled all the treatments during 2004-05. However, all the treatments except RDF and control during all the years along with Zn to linseed (2002-03), Zn to both the crops (2003-04) and Zn to either both the crops or individual crop (2004-05) were on par among themselves. Application of Zn to either one or both crops recorded numerically higher yield than 100% of recommended dose during all the years of experi-

mentation except 2004-05 where Zn to rice or linseed only were observed significantly superior to 100% RDF. Thus, Zn application only either in both the seasons or one season could not increase yield of rice significantly between 2002-03 and 2003-04 because the status of Zn of the soil was above the critical limit initially. The FYM application in rice along with Zn increased the rice yield numerically over all the schedules of Zn only. On pooled basis, Zn to rice only + FYM (T₅) was found 9.72%, 8.10%, 15.41% and 62.98% significantly superior to Zn to both crops, Zn to linseed only, recommended dose of NPK to both the crops and control. It is also clear that Zn to rice along with FYM increased the yield of rice significantly over recommended dose of NPK which was on par with all the treatments except Zn to both the crops without FYM. Thus, Zn application to both the crops *i.e.* 50 kg/ha zinc sulphate for the system, could not increase yield of rice significantly over recommended dose of NPK, whereas increase was significant when zinc sulphate was applied in one season only *i.e.* 25 kg/ha for the system. Similar results were also observed by Chaphale and Badola (1999). Application of FYM @ 5 t/ha along with Zn improved the yield of rice over respective Zn schedules but differences were not significant. Application of FYM might have improved the properties of soil (Bhatia and Shukla, 1982) which ultimately increased the yield of the crop.

Linseed yield

All the treatments were found to increase the seed yield over control and recommended dose of NPK but differences of all the treatments were significant only with control. Seed yield recorded in Zn to both the crops + FYM in rice (1.36 t/ha) during 2002-03 and Zn to linseed only +

Table 1. Impact of zinc and FYM in rice-linseed sequence on yield (t/ha) of rice and linseed.

Treatment	Grain yield of rice				Seed yield of linseed			
	2002-03	2003-04	2004-05	Pooled	2002-03	2003-04	2004-05	Pooled
T ₁ : Zn to both the crops	3.77	3.91	3.99	3.89	1.16	1.15	1.24	1.18
T ₂ : Zn to rice only	3.78	4.36	4.12	4.09	1.07	1.15	1.31	1.18
T ₃ : Zn to linseed only	3.50	4.26	4.09	3.95	1.04	1.18	1.31	1.18
T ₄ : Zn to both the crops + FYM in rice	3.80	4.08	4.45	4.11	1.36	1.28	1.40	1.35
T ₅ : Zn to rice + FYM in rice	3.82	4.58	4.40	4.27	1.20	1.28	1.44	1.30
T ₆ : Zn to linseed + FYM in rice	3.65	4.47	4.39	4.17	1.25	1.30	1.46	1.33
T ₇ : Recommended dose of NPK to both the crops	3.49	3.88	3.75	3.70	1.05	1.08	1.14	1.09
T ₈ : Control (No NPK, Zn, FYM)	2.34	2.58	2.93	2.62	0.72	0.56	0.49	0.59
SE m ±	0.01	0.02	0.09	0.08	0.06	0.08	0.03	0.05
CD (P=0.05)	0.31	0.50	0.29	0.22	0.18	0.25	0.10	0.15

Note: Zn, through zinc sulphate @ 25 kg/ha and FYM @ 5 t/ha.

Table 2. Effect zinc and FYM on linseed equivalent yield (t/ha) and economics ($\times 10^3$ Rs /ha) of sequence

Treatment	Linsed equivalent yield				Cost of cultivation*	Net monetary return*	B:C ratio*	Oil content (%)*	Oil yield* (kg/ha)
	2002-03	2003-04	2004-05	Pooled					
T ₁ : Zn to both the crops	2.46	2.49	2.47	2.47	29.81	13.76	0.46	39.03	462.0
T ₂ : Zn to rice only	2.37	2.65	2.57	2.53	29.37	15.25	0.52	39.50	464.7
T ₃ : Zn to linseed only	2.24	2.61	2.56	2.47	29.37	14.32	0.49	39.11	460.3
T ₄ : Zn to both the crops + FYM in rice	2.67	2.69	2.76	2.71	30.91	16.70	0.54	39.15	527.3
T ₅ : Zn to rice + FYM in rice	2.51	2.85	2.78	2.71	30.46	17.42	0.57	38.99	508.7
T ₆ : Zn to linseed + FYM in rice	2.50	2.83	2.80	2.71	30.46	17.29	0.57	38.42	513.3
T ₇ : RDF to both the crops	2.25	2.42	2.28	2.32	28.92	12.03	0.42	38.67	422.3
T ₈ : Control (No NPK, Zn, FYM)	1.53	1.45	1.38	1.45	21.19	4.60	0.22	39.28	231.0
SEm±	0.07	0.10	0.10	0.06		1.09		0.37	
CD (P=0.05)	0.21	0.30	0.29	0.18		3.31		NS	

*Mean of 3 years

FYM in rice during 2003-04 (1.30 t/ha) as well as 2004-05 (1.46 t/ha) were observed the highest but treatments of Zn to linseed + FYM during first as well as third year and all treatments except control during 2003-04 were observed at par in the respective years (Table 1). Application of FYM along with Zn increased the yield over respective schedule of Zn alone but increases were significant only during 2004-05. On pooled basis, Zn to both the crops + FYM in rice excelled all the treatments and was 14.41%, 23.85% and 128.81% superior to Zn application to both the crops, Zn to rice crop, Zn to linseed crop, recommended dose of NPK to both the crops and control, respectively. It is also clear that Zn application without FYM could not bring significant treatment differences over recommended dose of NPK mainly due to the initial Zn content of the soil which was above the critical limit. Nandanwar *et al.* (2000) achieved the similar results and observed increase in seed yield of linseed due to zinc application at Nagpur. Addition of FYM in zinc treatments brought increase in the linseed yield over respective schedule of Zn alone but the increase was significant when FYM was added along with Zn to both the crops and Zn to linseed only. Badiyala and Kumar (2003) also recorded increase in seed yield of linseed due to FYM application.

Linseed equivalent yield (LEY)

LEY differed among all the treatments significantly (Table 2) but was not observed consistent during all the years of experimentation. Application of Zn to both the crops + FYM in rice (2.67 t/ha) was observed superior during 2002-03, whereas Zn to rice only + FYM (2.85 t/ha) and Zn to linseed only + FYM (2.80 t/ha) were observed superior between 2003-04 and 2004-05, respectively. However, these treatments were observed at par

among themselves during all the years of experimentation. LEY recorded in the treatments of Zn without FYM was also numerically higher than recommended dose of NPK to both the crops. Application of Zn and FYM both in rice excelled all the treatments with 2.713 t/ha LEY on pooled basis, but was on par with Zn to both the crops + FYM in rice and Zn to linseed only + FYM in rice. The increase in the LEY due to treatments of Zn to both the crops + FYM in rice, Zn to rice + FYM in rice and Zn to linseed + FYM in rice were in order of 16.85%, 17.19% and 17.06% over RDF of NPK to both the crops (2.32 t/ha), respectively. The LEY recorded in Zn to both the crops and Zn to linseed only were also numerically higher over recommended dose of NPK to both the crops by a margin of 6.70%, and 6.65%, respectively. Application of RDF to both the crops brought increase in LEY by 59.32% over control.

Net monetary returns and B: C ratio

The effects of treatments were also observed significant in respect of net monetary returns (Table 2). Rice-linseed crop sequence fetched significantly maximum net monetary returns (Rs 17,419/ha) with Zn to rice only + FYM in rice over recommended dose of NPK to both the crops but it was on par with Zn to both the crops + FYM in rice and Zn to linseed + FYM in rice. The magnitude of increase due to application of Zn to both the crops + FYM in rice, Zn + FYM to rice and Zn to linseed + FYM in rice was found to be 38.81, 44.82 and 43.23%. In case of net monetary returns (NMR), Zn application alone resulted in significant increase of NMR with treatments of Zn to rice only (T₂) and Zn to linseed only (T₃). Addition of FYM in every Zn schedule brought numerical increase in NMR over zinc only in the order. The benefit

Table 3. Effect of Zn and FYM application in rice – linseed crop sequence on the N, P, K and Zn uptake (kg/ha) on poled basis.

Treatment	Rice				Linseed				Total			
	N	P	K	Zn*	N	P	K	Zn*	N	P	K	Zn*
T ₁ : Zn to both the crops	64.93	20.04	87.57	239.45	40.96	12.39	43.32	52.10	105.89	32.43	130.89	291.55
T ₂ : Zn to rice only	69.07	20.75	90.62	215.78	39.36	13.12	43.96	46.55	108.43	33.87	134.58	262.33
T ₃ : Zn to linseed only	68.72	20.81	89.85	212.09	39.40	13.00	44.31	47.10	108.12	33.81	134.16	259.19
T ₄ : Zn to both the crops + FYM in rice	78.37	23.74	104.40	271.39	50.15	14.45	53.60	71.17	128.52	38.19	158.00	342.56
T ₅ : Zn to rice + FYM in rice	80.66	23.77	107.66	262.78	47.95	14.64	55.12	58.52	128.61	38.41	162.78	321.30
T ₆ : Zn to linseed + FYM in rice	78.16	23.89	106.35	260.07	49.32	14.26	55.16	60.57	127.48	38.15	161.51	320.64
T ₇ : Recommended dose of NPK to both the crops	62.12	19.15	82.62	154.79	36.55	11.70	42.67	40.79	98.67	30.85	125.29	195.58
T ₈ : Control (No NPK, Zn, FYM)	32.27	9.64	41.01	109.38	17.42	6.07	23.71	20.77	49.69	15.71	65.32	130.15
SEM±	2.62	0.59	2.99	1.60	1.51	0.49	1.63	0.91				
CD (P=0.05)	7.95	1.79	9.08	4.85	4.57	1.50	4.95	2.76				

* uptake (g/ha)

Table 4. Effect of Zinc and FYM application on N, P, K (kg/ha) and Zinc (ppm) status of the soil after the harvest of third crop of linseed

Treatment	Available N		Available P		Available K		Available Zn	
	Actual	Change	Actual	Change	Actual	Change	Actual	Change
T ₁ : Zn to both the crops	202.00	22.00	22.35	2.35	246.50	6.50	0.96	0.11
T ₂ : Zn to rice only	201.53	21.53	22.69	2.69	246.48	6.48	0.92	0.07
T ₃ : Zn to linseed only	201.62	21.62	22.70	2.70	246.49	6.49	0.93	0.08
T ₄ : Zn to both the crops + FYM in rice	208.09	28.09	23.75	3.75	249.60	9.60	1.06	0.21
T ₅ : Zn to rice + FYM in rice	205.08	29.08	23.80	3.80	250.50	10.50	1.00	0.15
T ₆ : Zn to linseed + FYM in rice	207.14	28.14	23.80	3.80	250.30	10.30	1.02	0.17
T ₇ : Recommended dose of NPK to both the crops	203.23	23.23	22.90	2.90	247.50	7.50	0.73	-0.12
T ₈ : Control (No NPK, Zn, FYM)	154.14	-15.86	19.40	-0.60	228.00	-12.00	0.81	-0.04
Initial	180.00		20.00		240.00		0.85	

:cost ratio of the system was observed maximum when Zn was applied either to rice or linseed along with FYM to rice (1.57) against 1.42 of recommended dose of NPK in both the crops and 1.22 of control.

Oil content (%) and oil yield

Oil content recorded could not exhibit any significant treatment effect but oil yield differed among all the treatments significantly (Table 2). Application of zinc irrespective of season increased the oil content may be due to the beneficial impact of sulphur present in zinc sulphate in one hand and zinc on the other. Dubey *et al.* (2000) also observed increase in oil content of linseed due to sulphur application whereas, Saren and Sarkar (2007) recorded positive impact of Zn application on the oil content of groundnut. However, recommended dose of NPK to both the crops recorded lower oil content than control which confirms the finding of Redain *et al.* (1993). Zn to both the crops + FYM gave significantly higher oil yield than recommended dose of NPK to both the crops during all 3 years, however, Zn to linseed only + FYM was observed superior to all during 2004-05. The higher oil yields of these treatments seem to be associated with the higher seed yield of these treatments. Application of zinc to both the crops + FYM recorded maximum oil yield (527.33 kg/ha) on the basis of three years mean but Zn to rice only + FYM (508.67 kg/ha) and Zn to linseed only + FYM (513.33 kg/ha) followed it very closely.

Nutrient uptake

In general, nutrient removal by rice crop was recorded higher than linseed crop mainly due to higher yield of rice than linseed (Tables 1 and 3). The uptake of nutrients were increased significantly under all the treatments with the control both in rice and linseed. Both the crops were observed to remove significantly higher nutrients when treated with Zn + FYM when compared with recommended dose of NPK to both the crops, whereas the plots treated with Zn only could exhibit numerical superiority in this respect. However, the removal of NPK due to Zn application during both the seasons was observed numerically lower than its application during one season. Contrary to this, Zn application during both the seasons was observed significantly superior to its application during one season in respect of removal of Zn by both the crops. The maximum uptake of N, P and K was recorded with treatment Zn to rice + FYM. The Zn uptake in rice was found maximum with application of zinc in both crops with FYM. The uptake of N, P, K and Zn was recorded maximum with Zn to both the crops + FYM. Among the different schedules of Zn either with or without FYM, application of Zn to rice along with FYM removed higher N,

P and K but removal of Zn was higher when Zn was applied during both the seasons along with FYM to rice. It is also clear from Table 3 that application of FYM increased the uptake of the nutrients over their respective schedules of Zn application but difference between with and without FYM treatments were non significant. This may be due to favourable effect of physical and chemical environment of soil with FYM application which causes continuous supply of nutrients (Singh *et al.*, 2001).

Nutrient balance

The availability of nitrogen, phosphorus, potash and zinc in the soil after harvest of third crop of linseed was increased where these nutrients were added. The maximum gain in the availability of these nutrients was observed when FYM was added along with zinc. This increase was owing to better soil health due to application of FYM and partially due to application of recommended dose of NPK in both the crops which might have balanced the nutrient removal by these crops. Singh (2006) also reported the beneficial impact of FYM incorporation along with recommended doses of fertilizers in rice – wheat crop system. The availability of Zn in the soil was more pronounced when Zn was applied to both the crops than individual crop. However, it was maximum in the treatments of Zn to both crops along with FYM. The availability of N,P,K and Zn were decreased in the control plots from initial values on continuous cropping of rice and linseed grown in sequence. This decrease was due to non-supplement of these nutrients artificially. The availability of Zn was further decreased when recommended dose of NPK was given to both the crops may be due higher yield and uptake by both the crops in one hand and no application of Zn on the other.

REFERENCES

- Badiyala, D. and Kumar, S. 2003. Effect of organic and inorganic fertilizers on growth and yield of linseed (*Linum usitatissimum*) under mid-hill conditions of Himachal Pradesh. *Indian Journal of Agronomy* **48**(3): 220–223.
- Bhatia, K.S. and Shukla, K.K. 1982. Effect of continuous application of fertilizers and manures on some physical properties of eroded alluvial soil. *Journal of Indian Society of Soil Science* **30**(1): 333–336.
- Chaphale, S.D. and Badola, W.P. 1999. Response of rice (*Oryza sativa* L.) to zinc application. *Indian Journal of Agronomy* **44**(3): 538–543.
- Dixit, J. P., Chourasia, S.K., Pillai, P.V.A. and Khan, R.A. 1994. Assessment of flexibility of sowing time of linseed (*Linum usitatissimum* L.) varieties under double cropping system in Tawa command area. *Indian Journal of Agronomy* **39**(1): 105–109.
- Dubey, S.D., Husain, K. and Srivastava, R.L. 2000. Response of phosphorus and sulphur in linseed (*Linum usitatissimum* L.). *Advance Plant Science*. **13**(2): 535–538.

- Duncan, O.W. 1967. Correlation of zinc deficiency in linseed on the Darling Downs, Queensland. *Queensland Journal of Agricultural Science* **24**(2): 301–307.
- Mishra, J and Singh, R.S. 1996. Effect of nitrogen and zinc on the growth and uptake of N and Zn by linseed. *Journal of Indian Society of Soil Science* **44**(2): 338–340.
- Nandanwar, S.B., Chaphale, S.D., Badola, W. P. and Badola, R. P. 2000. Effect of sulphur and zinc on growth and yield of linseed. *Journal of Soils and Crops* **10**(2): 301–303.
- Redain, M, Singh, N.P., Singh, Subedar and Singh, S. 1993. Response of linseed (*Linum usitatissimum* L.) to irrigation and nitrogen application. *Annals of Agricultural Research* **14**(3): 269–275.
- Saren, B.K. and Sarkar, K. 2007. Response of groundnut (*Arachis hypogaea* L.) under different level of irrigation and Zn. *Journal of Oilseeds Research* **24**(1): 91–93.
- Singh, V. 2006. Productivity and economics of rice (*Oryza sativa*)–wheat (*Triticum aestivum*) cropping system in recently reclaimed sodic soil. *Indian Journal of Agronomy* **51**(2): 81–84.
- Takkar, P. N. and Nayyar, V. K. 1984. Response of crops to micro-nutrient applications. In: *Proceedings of FAI-NR Seminar on balanced fertilization programme with special reference to secondary and micronutrients of crops under intensive croppings*. FAI, New Delhi. pp. 95–124.