

EFFICIENT NUTRIENT MANAGEMENT FOR CROP QUALITY IN RICE-MUSTARD-MAIZE SYSTEM GROWN ON RECENTLY RECLAIMED SODIC SOILS

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ABSTRACT

An adaptive trial on farmer's field was conducted at village Jamon of Etah district during 2005-06 and 2006-07 on a fixed layout on recently reclaimed sodic soil to study the effect of nutrient management on quality of crops in rice-mustard-maize sequence. The treatment 125% STR (183, 77, 50 kg ha⁻¹ of NPK) gave the highest head rice recovery, starch content, amylopectin and lowest amylose content. In case of mustard, the highest oil content in seed was observed in 125% STR + 60 kg S ha⁻¹ and the treatment effects were significant. Mineral nutrition did not affect the proportion of constituent fatty acids. Numerically the lowest erucic acid content was observed in NPK SR (120, 60, 60 kg NPK ha⁻¹) + 60 kg S + 5 kg Zn ha⁻¹ and the highest oleic acid was observed in 100% STR + 60 kg S + 5 kg Zn ha⁻¹. The highest linoleic acid was present in 125% STR + 60 kg S + 5 kg Zn ha⁻¹ and there was a slight depression in erucic acid. The highest protein content in maize grain was recorded at 125% STR + 60 kg S + 5 kg Zn ha⁻¹. Addition of S and Zn improved the quality traits of all the three crops under study.

INTRODUCTION

Within the genetic confines, the plant composition undergoes profound changes due to environmental influences. Most of the agronomic and quality traits are most affected by genetic traits but within the genetic limits, genotype environment interactions play a major role in the chemical makeup of food crops (Dai *et al.* 1998). Among the environmental factors, nutrition helps in attaining the genetic limits. Major food components of food crops are carbohydrates, proteins lipids, minerals and water and sum total of the above components is yield obtainable from a crop. Qualitative and quantitative changes due to nutrient management have been reported by several workers in different crops (Pathak and Nigam 1981). Efficient nutrient management improved the quality composition of food 'ready to eat' in terms of its nutritional and market value (Good and Glending, 1998). Elaborate information on impact of efficient nutrient management on growth and yield of crop is available, nevertheless, the impact of the same on quality composition under various niches of multiple cropping system, is far less studied. Therefore, the present study was undertaken to gain systematic information on the effect of nutrient management on quality of crops in rice-mustard-maize system.

MATERIALS AND METHODS

An adaptive trial on farmer's field was conducted in Etah district during 2005-2006 and 2006-2007 on a fixed layout in a recently reclaimed sodic soil with pH. 9.1, EC 0.30 dSm⁻¹, available N 150 kg ha⁻¹, P₂O₅ 7.20 kg ha⁻¹, K₂O 180 kg ha⁻¹, S 4.5 kg ha⁻¹, Zn 0.46 mg kg⁻¹ G.R. 3.30 t ha⁻¹ and organic

carbon 1.6 g kg⁻¹. Varieties Usar-1, Varuna and Ganga-2 of rice, mustard and maize, respectively were taken for this study. The treatments for rice crop were control, NPK (SR-120 : 60 : 60), NPK (SR) + S₆₀, NPK (SR) + S₆₀ + Zn₅, 100% STR (147 : 62 : 40), 100% STR + S₆₀, 100% STR + S₆₀ + Zn₅, 125% STR (183 : 77 : 50), 125% STR + S₆₀, 125% STR + S₆₀ + Zn₅ and 150% STR (220 : 92 : 60) kg ha⁻¹ and for mustard crop-control, NPK (SR-120 : 60 : 40), NPK (SR) + S₆₀, NPK (SR) + S₆₀ + Zn₅, 100% STR (128 : 48 : 35), 100% STR + S₆₀, 100% STR + S₆₀ + Zn₅, 125% STR (160 : 60 : 44), 125% STR + S₆₀, 125% STR + S₆₀ + Zn₅ and 150% STR (192 : 72 : 53) kg ha⁻¹. Summer maize crop were grown on residual fertility after rice and mustard with a starter dose of 60 kg N ha⁻¹. Head rice recovery, amylose and amylopectin fractions of starch were analysed by the method McCready and Hassid (1943). The oil content of mustard seeds was determined by NMR on single point calibration by Soxhlet method. Fatty acid profile was analysed by gas chromatograph with flame ionization detector on 15% DEGS column after direct transmethylation of fatty acids into methyl esters (Luddy *et al.* 1968). The protein percent in maize was calculated by multiplying Kjeldahl nitrogen percent with 6.25. Crops were raised by adopting standard package of practices. At maturity the grain, seed and grain samples of rice, mustard and maize were collected.

RESULT AND DISCUSSION

Rice crop

Head Rice Recovery: The head rice recovery (unbroken rice) varied from 62% in control to 69% in

125% STR + 60 kg S + 5 kg Zn ha⁻¹, during the first year and the fertilizer doses 100% STR + S and above were significant from the control but the other treatments were not significant among each other except that 125% STR + 60 S kg + 5 kg Zn ha⁻¹, which was significantly superior to 100% STR + 60 kg ha⁻¹. During the second year it varied from 62% (control) to 70% (125%) STR + 60 kg S ha⁻¹ and 125% STR + 60 kg S ha⁻¹ + 5 kg Zn ha⁻¹ and the trend of results in second year was similar to those in

first year. It appeared that the higher fertilizer levels only were effective in increasing the head rice recovery. The head rice recovery data revealed that the treatment effects were significant and it increased with increasing levels of nutrients above 100% STR and the highest value was achieved in the treatment 125% STR + 60 kg S ha⁻¹ + 5 kg Zn ha⁻¹. It appeared that the fertilizer treatments resulted in soundness in grain health, which was helpful in the control of breaking of rice during milling (Kendurkar *et al.* 1999).

Table 1: Head rice recovery, starch, amylose and amylopectin of rice as affected by different treatments

Treatments	Head rice recovery (%)		Starch (%)		Amylose (%)		Amylopectin (%)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Control	62	62	67	68	34	33	66	67
NPK (SR)	63	63	68	69	32	33	68	67
NPK (SR) + S ₆₀	64	65	67	68	31	31	69	69
NPK (SR) + S ₆₀ + Zn ₅	64	65	69	69	31	30	69	70
100% STR	64	65	67	67	30	30	70	70
100% STR + S ₆₀	65	67	68	69	29	28	71	72
100% STR + S ₆₀ + Zn ₅	68	68	69	70	30	28	70	72
125% STR	67	68	69	71	28	29	72	71
125% STR + S ₆₀	67	68	70	71	28	28	72	72
125% STR + S ₆₀ + Zn ₅	69	70	70	72	29	28	71	72
150% STR	68	66	68	70	28	29	72	71
CD (P = 0.05%)	2.88	3.17	NS	NS				

Starch content

There were no large variations in the starch content due to different treatments and the results were not significant during both the years (Table-1). The fractionation of starch into amylose and amylopectin showed that amylose content varied from 28% to 34%, the highest being in control and lowest in 125% STR and the values were at par 125% STR + 60 kg S + 5 kg Zn ha⁻¹. The amylose content decreased and amylopectin increased proportionately due to fertilizer treatments, which showed that balanced nutrition at higher fertility levels resulted in the increase in amylopectin at the expense of amylose. The results of present study showed that the differences in the starch content of rice due to different treatments were not significant. The starch content is a varietal character and is not affected by environmental factors to any appreciable extent (Williams *et al.* 1958). However, the starch quality in terms of its fractions appeared to be affected by different treatments wherein the amylose content tended to decrease with proportionate increase in amylopectin at higher fertility levels, which is desirable cooking quality of rice (Juliano, 1997 and Verma 2010). The highest amylopectin was recorded in 125% STR + 60 kg S ha⁻¹ and 125% STR + 60 S kg ha⁻¹ + 5 kg Zn ha⁻¹.

Mustard

Oil content: Seed oil content varied from 41.25 to 44.70% and 42.45 to 44.88% during first and second year, respectively (Table-2). The NPK treatments did not differ significantly from control except 150% STR but all the treatment combinations of 100% STR and 125% STR along with S and S + Zn gave significantly higher values over control. The role of S in increasing oil content was more pronounced at each level of NPK. Pathak and Tripathi (1979) reported similar results. Good and Glending (1998) reported that 60 kg S ha⁻¹ increased the oil content from 43.73 to 44.07% in Canola (*Brassica napus*). Dubey and Shukla (1995), Mishra *et al.* (2002) and Karthikeyan and Shukla (2008) also reported an increase in oil content due to sulphur application.

Table 2: Oil percent in mustard seed as affected by different treatments

Treatments	2005-06	2006-07
Control	41.25	42.45
NPK (SR)	40.90	42.60
NPK (SR) + S ₆₀	42.22	43.00
NPK (SR) + S ₆₀ + Zn ₅	42.20	43.17
100% STR	41.50	42.90
100% STR + S ₆₀	43.40	44.75
100% STR + S ₆₀ + Zn ₅	43.41	43.95
125% STR	42.00	43.00
125% STR + S ₆₀	44.70	44.88
125% STR + S ₆₀ + Zn ₅	43.29	44.09
150% STR	42.48	43.51
CD (P=0.05)	0.97	0.90

Fatty Acid Profile

The range of variation in main fatty acids was as: Palmitic 2.75 to 3.90%, oleic 14.55 to 16.88%, linoleic 16.50 to 19.86%, linolenic 10.55 to 11.75%, ecosenoic 3.75 to 4.80% and erucic 45.0 to 48.15% during first year. During second year the corresponding ranges of variation were : palmitic 2.84 to 3.45%, oleic 16.75 to 18.55%, linoleic 19.29 to 21.97%, linolenic 8.45 to 9.20%, ecosenoic 3.45 to 4.70% and erucic 44.46 to 46.63%. The mean value of fatty acids of both the year are: myristic 0.9%, palmitic 3.17%, palmitoleic 0.11%, stearic 0.36%, Oleic 16.96%, linoleic 19.23%, linolenic 9.90%, eiconenoic 4.32% and erucic 45.98% (Table-3). The fatty acid profile was not much affected due to different treatments except that of NPK + 60 kg S + 5

kg Zn ha⁻¹ had a slight decreasing effect on erucic acid while higher doses of NPK increased it. Pathak and Nigam (1981) and Tiwari *et al.* (2004) reported that S application increased the concentration of nutritionally desirable fatty acids (oleic and linoleic) and decreased anti nutritional fatty acids (ecosenoic and erucic). Basumatary and Talukdar (2011) also reported significant increase in oil content, oleic and linoleic acids and significant decrease in erucic acid due to application of sulphur in rapeseed. Although the findings of present study are not perfectly in agreement with the above workers but the decreasing effect on eiconsenoic and erucic acids due to S application was evident. It can be concluded that S application brought about an improvement in the nutritional quality of oil.

Table 3: Fatty acid composition (%) of mustard seed oil as affected by different treatments

Treatments	Myristic	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic	Linolenic	Eicosenoic	Erucic
2005-06									
T ₁	0.10	3.55	0.12	0.41	15.22	18.22	11.24	4.47	46.67
T ₂	-	3.90	-	0.42	14.55	18.28	10.55	4.80	47.50
T ₃	-	3.66	-	0.38	15.76	18.30	10.95	4.00	46.95
T ₄	0.11	3.40	0.11	0.39	16.50	18.46	10.76	4.50	45.77
T ₅	0.15	3.43	-	0.41	16.62	18.06	11.00	4.75	45.58
T ₆	0.10	3.05	0.15	0.42	16.67	18.79	11.15	4.27	45.40
T ₇	-	2.96	0.11	0.42	16.88	18.44	11.75	4.44	45.00
T ₈	0.15	2.75	0.10	0.44	15.06	18.76	11.00	4.15	47.59
T ₉	0.11	3.00	-	0.47	16.12	18.42	11.45	3.95	46.48
T ₁₀	0.10	3.15	-	0.42	16.74	19.86	10.88	3.75	45.10
T ₁₁	-	3.21	-	0.41	16.85	16.50	10.78	4.10	48.15
Mean	0.10	3.28	0.12	0.42	16.09	18.37	11.05	4.29	46.38
2006-07									
T ₁	0.12	3.45	0.15	0.30	16.75	19.40	8.75	3.45	47.63
T ₂	0.01	3.05	0.12	0.31	17.82	19.50	9.20	4.40	45.50
T ₃	-	3.36	0.11	0.27	18.45	20.10	8.89	4.00	44.82
T ₄	0.11	2.97	0.08	0.28	18.55	20.40	8.45	4.70	44.46
T ₅	0.12	3.15	-	0.29	17.05	20.00	9.00	4.50	45.89
T ₆	0.05	2.89	0.14	0.22	17.75	21.41	8.76	3.90	44.89
T ₇	-	2.84	0.10	0.35	17.45	21.97	8.80	4.00	45.05
T ₈	0.11	3.01	0.12	0.30	18.01	19.42	8.45	4.12	46.46
T ₉	0.12	3.04	0.20	0.31	18.04	19.29	8.65	4.50	45.85
T ₁₀	0.10	3.04	0.12	0.32	18.44	19.56	8.43	4.31	45.68
T ₁₁	0.03	3.00	0.11	0.34	17.97	20.00	9.00	4.03	45.52
Mean	0.08	3.07	0.11	0.30	17.84	20.09	8.76	4.17	45.59
Mean of 2 years	0.09	3.17	0.11	0.36	16.96	19.23	9.90	4.32	45.98

Maize

Protein content: All the fertilizer treatments from NPK (SR) + 60 S + 5 kg Zn ha⁻¹ and onward gave significantly higher values than control, NPK (SR) and NPK (SR) + 60 kg S ha⁻¹ during both the years (Table 4). It appeared that higher levels of NPK were effective in increasing protein content over control

and SR during both the years. The protein content varied from 6.12 to 6.50% in first year and 6.21 to 6.62% during second year. The variation in the maize protein content under different treatments followed the same trends as reported by Sakal *et al.* (2000). Pathak *et al.* (1999) reported that K application had positive effect on maize protein content.

Table 4: Protein percent in maize as affected by different treatments

Treatments	2005-06	2006-07
Control	6.12	6.12
NPK (SR)	6.12	6.12
NPK (SR) + S ₆₀	6.25	6.34
NPK (SR) + S ₆₀ + Zn ₅	6.31	6.44
100% STR	6.31	6.37
100% STR + S ₆₀	6.37	6.50
100% STR + S ₆₀ + Zn ₅	6.44	6.56
125% STR	6.44	6.44
125% STR + S ₆₀	6.44	6.56
125% STR + S ₆₀ + Zn ₅	6.50	6.62
150% STR	6.37	6.56
CD (P = 0.05)	0.203	0.211

REFERENCES

- Basumatary, A. and Talukdar, M.C. (2011) Integrated effect of sulphur and farm yard manure on yield and quality of crops and nutrient status under rape-seed-rice cropping system in Fluventic Dytrochrept. *Journal of the Indian Society of Soil Science*, **59**(4) : 397-400.
- Dai, R.C., Xue, J.M., Wu, J.X. and Yang, Y. (1998) Genetic analysis of agronomic traits of rapeseed (*Brassica napus*, L.) at different boron levels. *Journal of Zhejiang Agriculture University*, **24** (3) : 248-253.
- Dubey, S. D. and Shukla, P. (1995) Effect of nitrogen, phosphorus and sulphur on the oil yield and oil quality of linseed. *Indian Journal of Agricultural Biochemistry* **8**(2) : 43-46.
- Good, A. J. and Glendining, J.S. (1998) Canola needs sulphur. *Better Crops International*, **12**(2) : 6-8.
- Juliano, B. O. (1997) A simplified assay for milled rice amylose. *Cereal Science Today*, **16** : 334.
- Karthikeyan, K. and Shukla, L. M. (2008) Effect of boron-sulphur interaction on their uptake and quality parameters of mustard (*Brassica juncea*) and sunflower (*Helianthus annuus* L.). *Journal of the Indian Society of Soil Science*, **56** (2) : 225-230.
- Kendulkar, P. S., Mohan, M., Vajpai, M., Yadav, S. S. and Srivastava, G. P. (1999) Laboratory manual on quality evaluation of cereals, pulses and oilseeds. *Department Agricultural Biochemistry*, C.S. Azad University of Agriculture and Technology, Kanpur, pp. 4-6.
- Luddy, F.E.; Barford, R.A., Herb, S. F. and Paul, M. J. (1968) A rapid quantitative procedure for the production of methyl esters of butter oil and other fats. *Journal of the American Oil Chemists Society*, **45** : 549-552.
- McCready, R. M. and Hassid, W. Z. (1943) The separation and quantitative estimation of amylose and amylopectin in potato starch. *Journal of the American Oil Chemists Society*, **65**: 1154.
- Misra, S. K., Singh, R. N., Tiwari, V. N. and Tiwari, K. N. (2002) Effect of sulphur fertilization on quality characteristics of mustard (*Brassica juncea*) seed in five cultivars. *Journal of Indian Society of Soil. Science*, **50**(1) : 141-143.
- Pathak, R. K. and Tripathi, R. D. (1979) Effect of sulphur application on the yield of oil and protein content of mustard. *Indian Journal of Agricultural Chemistry*, **12** : 151-157.
- Pathak, R. K., Tiwari, T. P. and Tiwari, K. N. (1999) Effect of potassium on crop quality in Uttar Pradesh. Proc. workshop on use of potassium in Uttar Pradesh Agriculture, held on June-15, organized by UPCAR and PPIC, Gurgaon, Haryana, pp. 112-119.
- Pathak, R.K. and Nigam, V. (1981) Studies on the oil content and oil quality of some toria (*B. campestris*) varieties grown in Uttar Pradesh. *Indian Journal of Agricultural Chemistry*, **14**(2) : 187.
- Sakal, R., Sinha, R. S., Singh, A. P., Bhogal, N.S. and Ismile, M. D. (2000) Influence of sulphur on yield and mineral nutrition of crops in maize-wheat sequence. *Journal of the Indian Society of Soil Science*, **48**(2) : 325-329.
- Tiwari, R., Verma, M. M. and Tiwari, K. N. (2004) Effect of sulphur application on seed and oil yields, sulphur uptake and oil quality of mustard. *Annals of Plant and Soil Research* **6**(2) : 105-108.
- Verma, P. K. (2010) Nutrient management in rice (*Oryza sativa* L.) crop for high sustainable yield and quality. M.Sc. (Ag.) Thesis, C.S.Azad University and Technology, Kanpur, pp. 42-43.
- Williams, Verginia R, Wu, WT, Tsai HY and Bates, H.G. (1958) Varietal differences in amylose content of rice starch. *Journal of Agricultural Food Chemistry*, **6** : 47.