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Direct and residual effect of integrated micronutrient application in soybean (*Glycine max*)–wheat (*Triticum aestivum*) cropping system

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ABSTRACT

A field experiment was conducted during 1997–2000 to study direct and residual effect of integrated micronutrient application on soybean [*Glycine max* (L.) Merr.]–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system. The results show that application of farmyard manure @ 10 tonnes/ha applied in rainy season (*kharif*) was found superior in total productivity of the system which was further confirmed by the highest values (0.82) of sustainable yield index. Stability analysis indicated that application of Zn @ 5 kg/ha to soybean (0.99), farmyard manure @ 10 tonnes/ha (0.92) and their integration (1.06) gave stable production over the years, while boron @ 0.5 kg + farmyard manure, Zn @ 5 kg + boron @ 0.5 kg/ha and seed treatment with sodium molybdate @ 4 g/kg seed showed stable performance under favourable environments. The seed treatment with sodium molybdate @ 4 g/kg seed was found most remunerative in soybean–wheat cropping system.

Kew words: Micronutrient, Farmyard manure, Soybean, *Glycine max*, *Triticum aestivum*, Wheat, Sustainable yield index

Nutritional management is one of the important constraints identified for restricting soybean productivity and adequate emphasis has not been given till date. Enhancement in soybean yield (Bhist and Chandel 1996) and its sustainability (Abrol and Palaniappan 1998) through nutritional management has been reported. Apart from limitations offered by major nutrients, correction of deficiency of zinc (Zn), boron (B) and molybdenum (Mo) in soils of Madhya Pradesh is of equal importance (Tandon 1991). The decline in application of organic manures like farmyard manure that can regulate the nutrient availability and sustain the productivity along with numerous other known advantages, need be refocused in conjugation with inorganics. Moreover, nutrient need of an individual crop and in cropping sequence is variable. Therefore, a study was conducted to evaluate the application of micro- and major nutrients with farmyard manure on productivity of soybean [*Glycine max* (L.) Merr.]–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cropping system.

MATERIALS AND METHODS

A field experiment was conducted at research farm, NRC for Soybean, Indore, Madhya Pradesh, during 1997–2000. The soil belonged to Sarol series, and analyzed: *p*H 7.6, EC 0.14 dS/m, organic carbon 0.45%, clay content 56.5%, $CaCO_3$ 6.2%, CEC 51.7 cmol/kg, Zn 0.6 ppm, B 0.16 ppm and Mo 0.05 ppm.

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The experiment consisted of 10 treatment combinations with 3 replications in a randomized block design (Table 1). Recommended levels of NPK (20:26:17 kg/ha to soybean and 120:26:34 kg/ha to wheat) were applied uniformly in all treatments. Farmyard manure (organic carbon 19.5%, N 0.72%, P 0.40, K 0.52, Zn 110 ppm, B 10.2 ppm, Mo 4 ppm) was applied at the time of last harrowing. 'PK 472' soybean followed by 'Sujata' wheat was grown following recommended package of practices. The fertilizer treatments (Zn @ 5 kg/ha, seed treatment with sodium molybdate @ 4 g/kg seed, boron @ 0.5 kg/ha, farmyard manure @ 10 tonnes/ha, Zn @ 5 kg/ha + farmyard manure @ 10 tonnes/ha, boron @ 0.5 kg/ha + farmyard manure @ 10 tonnes/ha, seed treatment with sodium molybdate @ 4 g/kg seed + farmyard manure @ 10 tonnes/ha, Zn @ 5 kg/ha + lime @ 2.5 kg/ha foliar spray at 25–30 days after sowing, Zn @ 5 kg/ha + boron @ 0.5 kg/ha as basal and control) were applied only to soybean crop and wheat was grown with recommended dose of fertilizers. The yield stability was computed following simple regression coefficient and mean over the years (Finlay and Wilkinson 1963). The type of stability is decided on regression coefficient (b), if 'b' is equal to unity, a treatment is considered to have average stability (same performance in all the environments), if 'b' is more than unity, it is suggested to have less than average stability (good performance in favourable environments 0 and if 'b' is less than unity, it is reported to have more than average stability (good performance in poor environments). The sustainable yield index was computed as mean yield–standard deviation/

Table 1 Effect of integrated micronutrient management on productivity, sustainable yield index, stability and economics in soybean–wheat cropping system (pooled data for 3 years)

Treatment	Seed yield (kg/ha)		Soybean equivalent yield (kg/ha)	Sustainable yield index			Stability index (b)			Net returns (Rs/ha)	B:C ratio	Cost of cultivation (Rs/ha)
	Soybean	Wheat		Soybean	Wheat	SEY	Soybean	Wheat	SEY			
Zn @ 5 kg/ha	1 583	3 969	4 158	0.43	0.89	0.78	0.97	0.54	0.99	23 692	2.60	14 770
Seed treatment with NaMoO4 @ 4 g/kg seed	1 609	3 927	4 156	0.47	0.88	0.72	0.94	0.34	1.31	25 937	3.07	12 506
Boron @ 0.5 kg/ha	1 513	4 034	4 130	0.48	0.74	0.80	0.86	1.78	0.74	25 232	2.94	12 971
FYM @ 10 tonnes/ha	1 684	4 279	4 460	0.50	0.88	0.82	0.92	0.75	0.92	20 755	2.01	20 500
Zn @ 5 kg/ha + FYM @ 10 tonnes/ha	1 595	4 050	4 222	0.43	0.82	0.63	1.00	0.94	1.06	16 284	1.72	22 770
Boron @ 0.5 kg/ha +FYM @ 10 tonnes/ha	1 539	3 991	4 128	0.40	0.88	0.75	1.02	0.74	1.12	17 213	1.82	20 971
Seed treatment with $NaMoO_4$ @ 4 g/kg seed + FYM @ 10 tonnes/ha	1 513	4 324	4 318	0.41	0.78	0.81	1.00	1.52	0.81	19 436	1.95	20 506
Zn @ 5 kg/ha + Lime @ 2.5 kg/ha foliar spray at 25–30 DAS	1 541	3 890	4 064	0.38	0.71	0.80	1.08	1.69	0.70	22 747	2.53	14 845
Zn @ 5 kg/ha + B @ 0.5 kg/ha as basal	1 516	4 031	4 131	0.37	0.79	0.72	1.10	1.37	1.19	22 971	2.51	15 241
Control	1 520	3 866	4 028	0.38	0.91	0.75	1.08	0.39	1.15	24 759	2.98	12 500
SEm±	17.55	48.08	36.66							1 058.90	0.16	361.16
CD ($P = 0.05$)	50	137	113							3 017	0.45	1 029

FYM, Farmyard manure; DAS, days after sowing

maximum yield (Singh *et al.* 1990). The economical parameters were computed by using the prevailing prices of inputs and outputs.

RESULTS AND DISCUSSION

Significant differences in yield of both the crops in comparison to the control were observed with the application of micronutrients with and without farmyard manure (Table 1). The highest soybean yield was recorded with farmyard manure @ 10 tonnes/ha that remained at par with seed treatment with sodium molybdate @ 4 g/kg seed, Zn @ 5 kg + farmyard manure @ 10 tonnes/ha and Zn @ 5 kg/ha clearly indicating the nutrient imbalance/deficit with respect to micronutrients. However, remaining treatments showed non-significant differences with the control. Application of farmyard manure alone showed an optimal improvement in yield attributes as compared to other treatments. Although, it is difficult to justify the non-response of seed treatment with $NaMoO_4$ coupled with farmyard manure addition, it can be attributed to low level of Mo in soil and its interaction with farmyard manure. Similar data were recorded by Joshi *et al.* (2000) and Billore *et al.* (1999). The highest yield of soybean recorded with farmyard manure could be attributed to sustained release of available nutrients during crop growth period (Rani Perumal *et al.* 1991). Chandel *et al.* (2002) also reported that the application of Zn @ 5 kg + farmyard manure @ 10 tonnes/ha in zinc deficient soils was found to be helpful for increasing soybean yield under Pantnagar environment in *Tarai* soils.

Growing wheat on fixed plots was utilized for assessment the residual effects of applied nutrients. Wheat yield was the maximum with seed treatment with sodium molybdate @ 4 g/kg seed + farmyard manure @ 10 tonnes/ha and remained at par with farmyard manure @ 10 tonnes/ha. The lowest wheat yield was recorded with control and showed non-significant differences with seed treatment with sodium molybdate @ 4 g/kg seed, B @ 0.5 kg/ha, and foliar spray of Zn @ 5 kg + lime @ 2.5 litre/ha at 30 days after sowing. Yadav and Kumar (2002) and Kumar *et al.* (2002) also reported that the farmyard manure application showed its positive residual response in succeeding wheat.

The system productivity was derived by computing the

soybean and wheat yields into soybean equivalent yield on prevailing prices basis. The maximum soybean equivalent yield was also associated with lone application of farmyard manure @ 10 tonnes/ha that was closely followed by the integration of farmyard manure + seed treatment with sodium molybdate @ 4 g/kg seed and showed superiority over the rest of the treatments. The lowest soybean equivalent yield was recorded with the control.

Sustainable yield index further confirmed that application of farmyard manure alone was more sustainable in soybean followed by lone application of B, Zn and Mo. While in wheat, it was highest with the control and remained at par with Zn @ 5 kg/ha, seed treatment with sodium molybdate, farmyard manure @ 10 tonnes/ha, and Zn @ 5 kg/ha + farmyard manure @ 10 tonnes/ha. The lowest sustainable yield index was with Zn + lime spray. When comparing the system productivity in terms of sustainability, maximum sustainable yield index was recorded with farmyard manure which remained at par with seed treatment with sodium molybdate with farmyard manure, Zn + lime spray, and B @ 0.5 kg/ha. The sustainable yield index values further confirmed superiority of organic manure application for providing the micronutrients to soybean-wheat system. Yadav and Kumar (2002) also viewed that the integration of inorganic fertilizers with organic manure (farmyard manure/green manure) has greater potential in stabilization of yield over a period of time.

The stability analysis indicated that application of micronutrients in conjugation of farmyard manure to soybean resulted in more stable performance than their lone application as evidenced from the b values, which were more nearer to unity. The application of Zn either lone or in conjugation of farmyard manure was found most stable as compared to other treatments. The application of Zn @ 5 kg/ha, farmyard manure (Nambiar and Abrol 1989), seed treatment with sodium molybdate + farmyard manure, Zn + lime spray appeared to perform better under stress situations owing to 'b' values lesser than unity (Billore *et al.* 1999 and Joshi *et al.* 2000).

Economical parameters revealed that seed treatment of sodium molybdate @ 4 g/kg seed was found most remunerative and also possessed highest benefit cost ratio which was closely followed by the control and B @ 0.5 kg/ha. The variations in economical parameters may be owing to the differences in input costs and output. The results clearly showed that there is a need to look into micronutrient requirement and also the sustainability of system. Summarizing the results, it can be suggested that practicing integrated application of recommended NPK fertilizer with organic manure in rainy season (*kharif*) (soybean–wheat cropping system) will not only be sufficient to meet the micronutrient demand of the crops but will stabilize productivity reasonably even under deviation from normal climatic environment.

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