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Enhanced Productivity and Income through Balanced Nutrition in Madhya Pradesh and Rajasthan Watersheds

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ABSTRACT: Community watersheds technically supported by the consortium of institutions adopt holistic system's approach as against the compartmental approach of soil and water conservation. ICRISAT-led consortium used characterization of soil resources in the benchmark watersheds (Semli and Shyampura Watersheds, Dewas district and Madhusudangadh watershed, Guna district in Madhya Pradesh and Bundi Watershed, Bundi district in Rajasthan) as an entry point activity. Stratified sampling of fields on a toposequence in the watersheds revealed widespread deficiency of multiple nutrients particularly Zn (67-100 %), B (72-100 %) with an exception of Guna and S (72-100 %) along with N and P which could be limiting the yield potential in the watersheds. Farmers' participatory research trials with different crops showed tremendous yield advantages upto 79 % over the farmers practice. The FPR trials also showed economic viability of amendment options with a net increased profit of Rs. 8190 ha^{-1} in case of wheat and Rs. 10740 with chickpea in M.P. watersheds. These FPR trials highlighted the urgency to provide right information about soil health to the farmers in time and empowering them to adopt balanced nutrient management strategies for increasing productivity and minimizing cost of inputs which are unnecessary.

Keywords: Micronutrient deficiencies, Rainfed crops, Participatory watersheds

The soils of Semi Arid Tropics (SAT) are generally marginal and highly degraded and combating land degradation and increasing productivity of drylands is a major challenge. Most of the dryland soils are low in organic carbon and deficient in major and micro nutrients. This offers a scope for improving the productivity with balanced nutrition. Increased use of chemical fertilizers as a source of major nutrients, combined with declining use of organic manures over time has led to large scale secondary and micro nutrient deficiencies (Srinivasarao *et. al.*, 2003). The deficiency of micronutrients is of critical importance for sustaining high productivity in many regions of India. Among these, Zn deficiency is more prevalent. Boron deficiency has become more critical for cropping systems on highly calcareous soils, sandy leached, limed acid and reclaimed soils (Takkar, 1996) However, most farmers in India apply only major nutrients that too in irrational quantities. ICRISAT-led consortium project adopted watersheds as operational units for soil and water conservation as an entry point for agricultural research and development (Wani *et. al.*, 2002). Rego *et. al.*, (2005) reported the large scale benefits in different dryland crops due to micronutrient application in Andhra Pradesh. In the present study, watersheds in Vidisha, Guna and Dewas districts (Madhya Pradesh) and Bundi (Rajasthan) were included to examine the impact of balanced nutrition on productivity of dryland crops.

Materials and Methods

Most of the watersheds in India are about 500 ha (micro-watersheds) and number of farmers cultivating the arable land varied across the watershed. Prior to interventions through on-farm trials, soils of these watersheds were characterized for physico-chemical properties. Details of limiting nutrients in the soils of farmers' fields are presented in Table 1. Organic C was determined using the Walkley-Black method (Nelson and Sommers, 1996); available P was measured using the sodium bicarbonate ($NaHCO_3$) extraction (Olsen and Sommers, 1982). Exchangeable K was determined using the ammonium acetate method (Helmke and Sparks, 1996). Available S was measured using 0.15 % calcium chloride ($CaCl_2$) as an extractant (Tabatabai, 1996). Available Zn was extracted by diethylene triaminepentaacetic acid (DTPA) reagent (Lindsay and Norvell, 1978) and available B was extracted by hot water (Keren, 1996). Based on this soil test data, treatments of balanced nutrient application were composed and selected farmer's evaluated these treatments with ICRISAT facilitation in all these districts. Different nutrient management options along with farmer's practice of using N and P were studied in different watersheds during 2001-2005. Large number of on-farm trials involving major crops: sorghum, soybean, chickpea, wheat, maize and blackgram were conducted. Variations in the different genotypes of soybean (Bagli), chickpea and wheat (Madhusudangadh) to different nutrient management options were evaluated in the farmer's fields. Economics of balanced fertilization were worked out for some of the crops.

Results and Discussion

Nutrient deficiencies in watershed soils

Soil texture was clay in Madhya Pradesh watersheds and sandy loam in Rajasthan watershed. All the soils were alkaline in reaction showing pH above 7.0 and there was no salt related problem in the soils. Soils were low to high in organic carbon, P, K and S. Available Zn and B were also varied from deficient to sufficient levels. Per cent P deficient farmers fields varied from 53 (Bundi) to 96 (Dewas) (Table 1). Higher K deficiency was found in Bundi district up to 18%. Per cent S deficient fields ranged from 72 (Bundi) to 100 (Dewas). Available B deficient fields varied from 0% (Guna) to 100% (Dewas). Similarly, Zn deficient fields varied from 67% (Bundi) to 100% (Vidisha and Dewas). Extent of secondary and micro nutrient deficiencies are in accordance to earlier reports by Tandon (1991), Takkar (1996), Srinivasarao *et al.* (2003) and Rego *et al.* (2005).

Responses to secondary and micronutrients Semli and Shyampura Watersheds, Bagli, Dewas

Effect of balanced nutrient application in Bagli watershed in Dewas (M.P.) showed (Table 2) that inclusion of S+Zn+B (200 kg gypsum+25 kg $ZnSO_4$ ha^{-1}+5kg borax) along with farmer's practice of applying only N and P. Sorghum yields improved by 60% at Bagli village, while soybean yields improved by 75%-79% at Semli.

Madhusudangadh watershed, Guna (M.P.)

In the Madhusudangadh watershed (Guna, M.P), effects of balanced nutrition was tested with four chickpea varieties during post rainy season of 2004, 2005 and soybean during rainy season. The treatments tested were T1=Farmer's practice (FP), T2=FP+Zn+S+B, T3=Zn+ S+B+optimum NP and T4=Farmer's practice+optimum NP. The quantity of nutrients added were as follows: Zn as $ZnSO_4$@50 kg ha^{-1}, S as gypsum @ 200 kg ha^{-1}, boron as borax@5 kg ha^{-1}, N and P were applied at 30 and 60 kg ha^{-1} respectively. The four improved chickpea varieties grown were KAK 2, ICCV 2, ICCV 10 and ICCC 37. The highest grain (2.24 t ha^{-1}) and straw (1.83 t ha^{-1}) yield was recorded in T2 treatement with KAK 2 variety, whereas other three varieties produced the highest grain and straw yields in T3 treatment (Table 3). Similarly, in soybean, Zn+S+B+optimum NP recorded highest grain and straw yield compared to other nutrient treatments. Wide variation in micronutrient nutrition (Zn, Fe, Mn and Cu) of twenty chickpea genotypes was reported in multi-nutrient deficient Typic Ustochrepts (Srinivasarao *et al.*, 2006).

Vidisha watersheds (M.P.)

Experiments were carried out to study the impact of fertilizers on yield of chickpea with four levels of fertilizers i.e., T1 = Control (farmer's practice); T2 = Zn through $ZnSO_4$ @ 50 kg ha^{-1}; T3 = S through gypsum @ 200 kg ha^{-1}; T4 = Zn+S; and T5 = $ZnSO_4$@50 kg ha^{-1} + gypsum@100 kg ha^{-1} + SSP@100 kg ha^{-1} and the results obtained with the balanced application of fertilizers. The results showed that the improved varieties alone in control plots yielded 10 to 43% more than the farmer's variety. Further application of micronutrient amendments in local as well as improved varieties increased grain and straw yields significantly up to 70% over the untreated control. A quantitative analysis of response of different pulse crops to applied S showed an yield increases of 100 to 500 kg ha^{-1} in 80 per cent cases and 250 to 500 kg ha^{-1} in remaining cases (Tandon, 1991).

As reported earlier the soils in Madhya Pradesh are deficient in number of micronutrients along with the macro elements such as nitrogen and phosphorus. Farmers continued their experimentation with the micronutrient amendments during the *rabi* season with chickpea and wheat crops (Table 4). In case of chickpea significantly higher grain (21.75 q ha^{-1}) and straw yield (25.9 q ha^{-1}) was recorded in plots that received Zn + S + SSP. An increase in grain yield to the tune of 63.6 per cent due

Table 1. Limiting nutrients in soils of different districts of M.P. and Rajasthan watersheds

Parameter	Madhya Pradesh		Rajasthan	
	Vidisha(31)*	Dewas (24)	Guna(18)	Bundi (36)
Organic carbon (%)	0.46-0.92(10)**	0.30-1.00(17)	0.51-1.11(0)	0.18-1.17(39)
Available P (mg kg^{-1})	0.50-14.1(90)	0.20-10.8(96)	0.10-8.40(72)	0.90-20.1(53)
Available K (mg kg^{-1})	97-285(0)	46-456(4)	86-179(0)	23-563(18)
Available S (mg kg^{-1})	2.9-9.8(100)	3.9-9.5(100)	2.7-14.3(89)	3.3-50.9(72)
Available Zn (mg kg^{-1})	0.10-0.42(100)	0.12-0.56(100)	0.24-1.74(78)	0.20-1.80(67)
Available B (mg kg^{-1})	0.12-0.34(100)	0.20-0.80(96)	0.60-2.20(0)	0.10-0.98(72)

* No of farmer's fields; ** Percentage deficient

Table 2. Effect of balanced nutrient application on crop yields in Bagli watersheds, Dewas (M.P.)

Parameter	Bagli		Semli		Shyampura	
	FP+S+Zn+B	FP	FP+S+Zn+B	FP	FP+S+Zn+B	FP
Crop	Sorghum	Sorghum	Soybean	Soybean	Soybean	Soybean
Variety	JJ1041	JJ1041	JS-9305	JS-9305	JS-335	JS-335
Yield (kg ha^{-1})	3360	2100	700	400	2000	1120
Yield increase						
Over control(%)	60	-	75	-	79	-

FP=Farmer's Practice

Table 3. Impact of application of fertilizers on grain and straw yield of different cultivars of chickpea (q ha^{-1}).

Treatment	Local		ICCV-2		ICCV-10		ICCC-37		KAK-2	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Control	8.78	11.46	12.00	13.43	11.96	13.93	9.70	12.10	12.60	15.86
Zn	9.23	9.13	13.33	16.40	13.70	16.13	12.40	14.3	18.96	19.80
S	9.86	11.93	14.90	19.43	13.26	16.16	12.83	14.83	16.16	18.86
Zn + S	11.16	14.03	16.23	17.60	15.16	16.26	12.16	15.26	18.10	19.90
Zn+S+SSP	11.65	16.36	17.33	17.53	16.80	18.40	16.50	15.8	21.46	22.3

to application of single super phosphate along with zinc and sulphur was recorded over the untreated control. In other treatments with micronutrient amendments, the increased grain yields varied from 31 to 54 per cent over the untreated control plot yields. Chickpea grain yield in case of Zn + S treatment was on par with the grain yield from the SSP+Zn+S treatment plot. The economic analysis showed that the highest B:C ratio of 2.63 was observed in case of Zn + S + SSP treatment and followed by 2.59 in case of Zn + S treatment (Table 4). Based on 12 on-farm trials, Singh (1999) reported that benefit :cost ratio was 19.7 in case of chickpea. Response to B application was largely obtained on calcareous and sandy alkaline soils (Takkar, 1996).

In case of wheat the response to best-bet treatment (Zn + S + SSP) (31.50 q ha^{-1}) was spectacular i.e., 40 per cent increase over control (22.4 q ha^{-1})(Table 5). Similar increased yield of straw was also observed due to amendments with the micronutrients. The economic analysis of these experiments showed that net profit of Rs. 21720/- per ha was obtained in case of the best-bet treatment with a cost:benefit ratio of 1:2.32. Even the application of sulphur alone also benefited the farmers to the tune of Rs. 20540/- per ha suggesting that these soils are severely deficient in S than the P which is supplied through SSP.

Bundi watershed, Bundi (Rajasthan)

At Bundi watershed, balanced nutrition trials were conducted with maize and urdbean in rainy season and wheat and chickpea in post-rainy season (Fig. 1). The treatments were: T1= Farmer's practice, T2= Farmer's practice + borax 5 kg ha^{-1} + Gypsum 200 kg ha^{-1} + $ZnSO_4$ 50 kg ha^{-1}, T3= Farmer's practice+ borax 5 kg ha^{-1} + gypsum 200kg ha^{-1} + $ZnSO_4$ 50 kg ha^{-1} + urea 100 kg ha^{-1} + DAP 100 kg ha^{-1} and T4= Farmer's practice+urea 100 kg ha^{-1}+DAP 100 kg ha^{-1}. For all the crops, T3 treatment showed consistently superior yields compared to other treatments. The percentage increase in crop yields in T3 over T1(Farmer's practice) was highest in urdbean (47%) followed by maize (45%), chickpea (43%) and wheat (16%). The economic analysis showed that the highest B:C ratio was obtained in case of balanced nutrition treatment as compared to farmers practice. These results clearly show that balanced nutrition, based on the application of limiting nutrients is essential for improving productivity of various dryland crops.

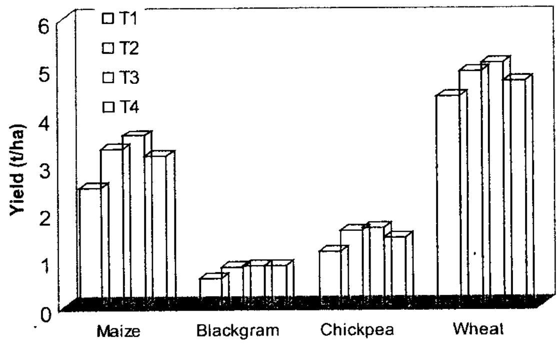

Figure 1. Effect of different nutrient management options on average crop yields at Bundi Watershed

Table 4. Effect of micronutrient amendments and best-bet option treatments on grain and straw yield and economics of chickpea, 2002-2003, Guna.

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit:cost ratio
Zinc (Zn)	18.70	21.20	12499	32053	19554	2.56
Sulphur (S)	17.50	21.30	12227	30131	17904	2.46
Zn + S	20.50	23.90	13569	35206	21637	2.59
Zn + S + SSP	21.75	25.90	14206	37386	23179	2.63
Control	13.30	16.50	10480	22918	12437	2.18
SE (m) ±	0.69	0.51	-	94.59	71.66	0.052
CD at 5%	1.87	1.43	-	280	215	0.13
General mean	18.35	21.75	12596	31538	18942	2.48

Table 5. Effect of micronutrient amendments and best-bet option treatments on grain and straw yield and economics of wheat, 2002-2003, Guna.

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Benefit: cost ratio
Zinc(Zn)+FP(N+P)	26.90	32.20	14460	31470	17010	2.17
Sulphur (S)	3070	36.40	15220	35760	20540	2.34
Zn + S	28.90	36.70	15410	33900	18490	2.20
Zn + S + SSP	31.50	41.30	16380	38100	21720	2.32
Control(FP: N+P)	22.40	28.30	13170	26700	13530	2.02
SE (m) ±	0.71	0.66		107.61	96.65	0.04
CD at 5%	1.97	1.84		311	289	0.11
General mean	28.07	34.98	14926	33185	18259	2.21

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