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Sustaining farm productivity through watershed based participatory balance nutrient management: A case study from Semi-Arid Tropics of central India

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ABSTRACT

Participatory trials on balance nutrients were conducted during 2009-12 in a severely micronutrient deficit semiarid central Indian watershed to promote balance use of nutrients. Application of micronutrient increased groundnut pods plant^{-1} by 9%, seeds pod^{-1} by 6% and pod yield by 13% (1132 kg ha^{-1}) compared to control in entry point trials. Similarly, chickpea variety "JG-130" grown with balance fertilizers also recorded 15 and 40% higher grain yield compared to "JG-130" and local chickpea variety, respectively grown with traditional practice. Application of B, Zn and S increased mean groundnut pod yield by 16.8% over control in further up scaling trials. The study on residual effect of balance fertilization indicated that grain yield of succeeding wheat, barley, chickpea and mustard increased by 8.3, 10, 8.8 and 9.2%, respectively. Further, the sustainability index of direct balance fertilization to groundnut was 0.8 and it was 0.76, 0.74, 0.76 and 0.83 in residual effect in succeeding wheat, barley, gram and mustard, respectively. Although nearly 88% farmers were convinced by the impact of micronutrients, but only 9% farmers actually used them in *kharif,* 2012 and availability of micronutrients emerged as the major hurdle in up scaling.

1. INTRODUCTION

Soil fertility crisis is being viewed as the biggest threat to agricultural productivity, profitability and sustainability (Takkar, 1996). A big challenge for agriculture scientists, farmers and planners over the coming decades will be meeting world's increasing food demand from degrading natural resource base (Palsaniya *et al.,* 2012a). The practice of intensive agriculture in terms of raising more crops per unit time and over use of high analysis fertilizers has resulted in faster depletion of secondary and micronutrient reserves from Indian soils (Vasuki, 2010; Palsaniya and Ahlawat, 2007). Analysis of 3,00,000 soil samples from across the country indicated that the average deficiency of Zn, Fe, Mn and Cu in Indian soils was 49, 12, 4 and 3%, respectively (Shukla *et al*., 2012). Similarly, analysis of 50,000 samples showed B and Mo deficiencies in 33 and 12% of the soil samples, respectively. Further, it is estimated that approximately 68 mha area (49% of cropped land) is suffering from S deficiency in India (The Financial Express, 2006). None of the farmers in Bundelkhand are applying micro and secondary nutrients to their field crops (Palsaniya *et al*., 2008, 2009). Instead of single nutrient deficiency, multi-nutrient deficiencies are emerging fast in vast areas of India which are not only affecting the crop productivity but also creating malnutrition and health related problems (Vasuki, 2010; Rattan *et al.,* 2009). The deficiency of micronutrients is becoming a limiting factor for sustainable productivity in many soils in spite of application of recommended dose of NPK (Swarup, 1998) and therefore, sustainable increase in farm productivity is not possible without ensuring adequate and balance supply of nutrients to crops.

Enhanced productivity due to balance fertilizer application (including micronutrient) has widely been reported from across the country and for wide variety of crops (Kokate *et al*., 2012; Shukla and Behera, 2012; Palsaniya and Ahlawat, 2009; Saxena, 1995; Rego *et al*., 2005; Vasuki, 2010; Rattan *et al.,* 2009). Saxena (1995) observed that balance fertilization is necessary for sustainability over time. He showed that wheat yields became uneconomical after 5 years when only N fertilizer is applied. Even annual field applications of NP and NPK fertilizers were insufficient to sustain yields over the long term and when balanced fertilizers were applied, yields increased and fields remained productive despite continuous cultivation. Shukla and Behera (2012) provided a critical review of response of various crops to micronutrient fertilizer use. They reported 160 to 513 kg ha^{-1} increase in average productivity level due to Zn application and opined that proper management of Zn alone could contribute18.5 m tones to the total food grain production. Similarly, the average increase in productivity of pulses, oilseeds and cereals reported across the country were 34.5, 19.5 and 16.5% higher due to B application over the NPK. Recently, Kokate *et al.* (2010 and 2012) had highlighted the advantages in increasing the productivity of various crops such as cereal, coarse cereal, oilseeds, pulses, vegetable and food crops due to balance fertilizer application from the data generated by the Krishi Vigyan Kendras (KVKs) under on-farm conditions from various parts of India. Palsaniya and Ahlawat (2009) reported that application of 30 kg S ha^{-1} to pigeonpea increased its grain yield by 470 kg ha^{-1} compared to control. While investigating direct and residual effect of S in pigeonpea-wheat cropping system, they revealed that S applied to pigeonpea at 60 kg ha^{-1} left behind 1.19 kg ha^{-1} more S in soil than 30 kg ha^{-1} which further resulted in higher grain yield of succeeding wheat by 580 kg ha^{-1}.

It is repeatedly being emphasized that the current adoption rate of improved agro-techniques by Indian farmers is very poor. As an alternative, Farmers Participatory Research, which was started in 1980s, emphasizes on-farm research with active participation of farmers so that these agro-techniques may readily be adopted. The watershed projects in recent times are being implemented in participatory mode as per the New Common Guidelines for Watershed Development Projects in India 2008. Participatory integrated watershed management has been a prominent approach not only for resource conservation, livelihood security and agricultural sustainability (Palsaniya *et al*., 2012a, 2012b, 2011; Samra, 1997; Wani *et al.,* 2007) but also being used as a vehicle for transfer of improved agro techniques to farmers (Palsaniya *et al.,* 2012b, 2010). The work done and experience gained on participatory balance fertilization and micronutrient use in such a model watershed project is being presented as a case study in this paper.

2. MATERIALS AND METHODS

Study Site Profile

The present study was conducted at Domagor-Pahuj watershed located in Babina block of Jhansi (Uttar Pradesh) where National Research Centre for Agroforestry (NRCAF), Jhansi is developing a model watershed in consortium mode with International Crop Research Institute for Semi Arid Tropics (ICRISAT), Hyderabad and Development Alternatives (NGO), Jhansi based on Common Guidelines for Watershed Development Projects, GoI, 2008 (Fig. 1). This watershed is located between 25º28'16" to 25º31' N Latitude and 78º25' to 78º 28' and 8" E Longitude. The treatable area of watershed is 1373 ha. The watershed comprises of three villages namely, Domagor, Dhikauli and Nayakhera. Detailed baseline survey indicated that the main source of livelihood is agriculture, animal husbandry and farm labour. Majority of the farmers are small and marginal. The main *kharif* crops were groundnut, blackgram, greengram, sesame, sorghum and maize while major *rabi* crops were wheat, chickpea, mustard and lentil. The productivity of crops is low as compared to other regions of the state. Open dug wells are the main source of irrigation. The agricultural land is sloppy and has multidirectional complex slopes.

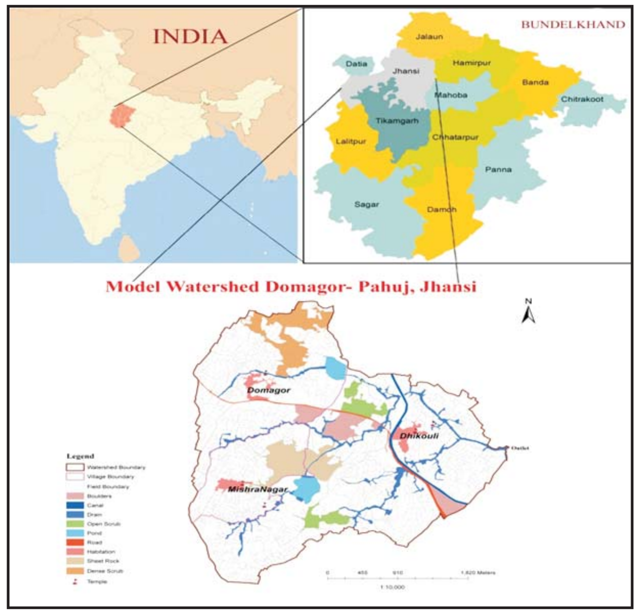

Fig.1. Index Map of Domagor Pahuj watershed

Initial Soil Fertility Status

The predominant soil order is Alfisol (red soil) with some black soil patches in low lying areas. To ascertain the soil fertility status of watershed, 80 representative soil samples were drawn, processed and analyzed at International Crop Research Institute for Semi Arid Tropics (ICRISAT), Hyderabad. The pH and electrical conductivity (EC) varied from 7.0 to 8.5 and 0.04 to 0.50 dS m^{-1}, respectively. The 50% of soil samples had organic carbon less than 0.5%. Nitrogen, phosphorus and potassium were low in 56, 18 and 25% samples, respectively. Alarmingly, Zn, B and S were deficit in 58, 99 and 91% soil samples, respectively in the watershed area.

Methodology

Realizing the widespread deficiency of micronutrients in Domagor-Pahuj watershed, it was decided to conduct micronutrient based participatory trials as entry point activity (EPA) to promote balanced fertilization. Accordingly, two groundnut varieties "ICGV-91114" and "ICGS-44" along with local Jhumku during *kharif*, 2009 and chickpea variety "JG-130" during *rabi,* 2009-10 were grown with and without micronutrients in on-farm trials in watershed in participatory mode. In case of groundnut, each one acre field of farmer was divided into six blocks of equal size and above three varieties were grown with and without micronutrients. Similarly, in case of chickpea, the farmer's field was divided into three blocks and "JG-130" was grown with and without micronutrients and also compared with local variety grown with traditional package of practice. The number of trials in groundnut and chickpea were nine and sixty, respectively. Further, inspired by the impact of micronutrients in above trials, twenty nine more participatory trials were conducted with local groundnut variety during *kharif,* 2011 for up-scaling and to promote balanced fertilization and their residual effect was monitored in subsequent crops (wheat, barley, chickpea and mustard) grown during *rabi,* 2011-12. Local varieties of above crops were raised (except barley; "Narendra 2" var.) with traditional package of practices.

Groundnut was raised as per standard package of practices and applied with recommended dose of fertilizers, gypsum @ 200 kg ha^{-1}, zinc sulphate @ 25 kg ha^{-1} and Agribor (for B) @ 2.5 kg ha^{-1}. Disodium Octaborate Tetrahydrate ($Na_2B_8O_{13}.4H_2O$) is marketed in the trade name of Agribor and contains 20% Boron while Zinc Sulphate (Agriculture grade $ZnSO_4$) contains 21% Zn and 10% S. They were applied directly to soil through broadcasting during field preparation before sowing. Groundnut was sown in second week of July and last week of June in 2009 and 2011, respectively and harvested during third week of October during both the years. In case of chickpea, "JG-130" was sown in second week of October, 2009. The 2009-10 crops of groundnut and chickpea were taken as rainfed while 2011-12 crops were taken as irrigated (groundnut, 2-3 irrigations; wheat, 4-5 irrigations; barley, 1-2 irrigations; chickpea, 1irrigation and mustard, 1irrigation). All the participatory trials were of one acre each.

To monitor the impact of balanced fertilization (micronutrient), uniform crop sampling was done. Five samples each of 3x3 m size were taken as per treatment (with and without micronutrients and traditional practice) from each trial at harvest and biometric observations were recorded for each crop. The Sustainability Index (SI) of balanced fertilization was calculated using following formula. SI = (Y_{mean} - Standard Deviation)/ Y_{max} where Y_{mean} is the mean yield of crop and Y_{max} is maximum yield. In order to know the adoption behaviour and hurdles in adoption of micronutrient use, 80 farmers from the watershed were interviewed through well structured questionnaire. They included participating and non participating farmers as well.

3. RESULTS AND DISCUSSION

Micronutrient Based Entry Point Activities (EPAs)

The analysis of soil showed widespread deficiency of zinc, sulphur and boron in the watershed area. Therefore, it was decided to conduct micronutrient based EPAs in groundnut and chickpea in the watershed. Application of balanced fertilizers (RDF+micronutrients+S) significantly enhanced growth, yield attributes and yield of groundnut in participatory trials during *kharif*, 2009 (Table 1). Micronutrient increased groundnut pods/plant by 9%, seeds pod^{-1} by 6%, 1,000-grain weight by 4%, pod yield by 13%, haulm yield by 14%, biological yield by 13% and shelling by 2% compared to crop raised without micronutrient. The local variety Jhumku performed better as compared to the newly introduced varieties. Jhumku recorded 26.4 and 21.3% higher pod yield over "ICGV-91114" and "ICGS-44", respectively. This might be due to the fact that these new varieties started 10-15 days early flowering than Jhumku and there was a dry spell of 21 days during this period which resulted in poor flowering and pegging in these varieties. Rego *et al.* (2007) also reported that the percentage increase in pod yield of groundnut due to the application of S, B and Zn over the farmers practice were 33, 48, and 29 during 2002, 2003 and 2004, respectively in participatory trials.

The Chickpea variety "JG-130" grown with balanced fertilizers (RDF+micronutrients+biofertilizers) under rainfed condition also recorded 15 and 40% higher grain yield, respectively compared to "JG-130" and local chickpea variety grown with traditional practice without micronutrients (Fig. 2). This showed the potential of micronutrients even under rainfed condition. Further, farmers can get 22% higher grain yield simply by growing

Table: 1
Groundnut varieties with micronutrients in on-farm trials

Treatment	Pods $Plant^{-1}$	Seeds Pod^{-1}	1000-Seed weight (g)	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)	Shelling (%)
Variety								
"ICGV-91114"	10.2	1.81	330.5	969	2130	3099	31.3	67.2
"ICGS-44"	11.0	1.94	335.8	1010	2313	3323	30.4	68.3
Jhumku	12.4	2.10	345.2	1225	2793	4018	30.5	65.8
SEm	0.4	0.05	3.3	68.4	154	224	0.4	0.45
CD at 5%	1.2	0.14	9.7	202	452	658	1.0	1.3
Micronutrient								
With*	11.7	2.01	343.2	1132	2566	3698	30.6	67.7
Without	10.7	1.89	331.2	1005	2257	3262	30.8	66.5
SEm	0.3	0.03	4.1	40.8	99	142	0.2	0.4
CD at 5%	0.9	0.10	10.2	119	289	414	NS	1.1

*Gypsum @ 200 kg ha^{-1} + Zinc Sulphate @ 25 kg ha^{-1} + Agribor @ 2.5 kg ha^{-1}

improved high yielding chickpea variety like "JG-130" compared to local variety. Rego *et al*. (2005 and 2007) also showed similar encouraging yield increase in these crops from watershed based participatory trials conducted in Andhra Pradesh, Maharashtra, Karnataka and Rajasthan.

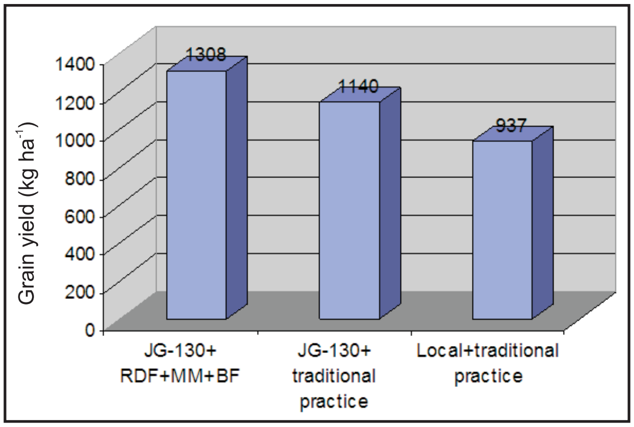

Fig. 2. Performance of chickpea (*rabi*, 2009-10)

Where, RDF = recommended dose of fertilizer, MM = micronutrient mixture @ 12.5 kg ha^{-1} (containing 6% zinc, 3% Fe, 1.5% Mn and 0.5% Ca) and BF=Biofertilizer - *Rhizobium* and PSB

Up Scaling Micronutrient Use

To promote further use of micronutrients, twenty nine more participatory trials were conducted during *kharif*, 2011 under irrigated conditions in groundnut and residual effect was monitored in subsequent crops grown during *rabi,* 2011-12 (Table 2 and Table 3). Twenty trials were monitored for data collection. The irrigation facilities were developed within watershed through conservation activity. Agribor (B), Zinc Sulphate (Zn) and Gypsum (S) were provided at 50% cost from the project and rest of the inputs were managed by farmers themselves. The average productivity of groundnut with balanced fertilization under these participatory trials was 1842 kg pods ha^{-1} with range of 1625 to 2120 kg ha^{-1}. However, mean groundnut pod yield without micronutrients and S was 1577 kg ha^{-1} with range of 1370-1895 kg ha^{-1}. It was observed that application of B, Zn and S increased the groundnut pod yield by 16.8% over control. The range of response of groundnut to balanced fertilization was 5 to 33%. The Sustainability Index (SI) of balanced fertilization to groundnut was as high as 0.8. The beneficial effects of balanced fertilization may be attributed to the better growth and productivity of crops which resulted in lower production costs, better profitability, improved chances for producing a good yield under adverse climatic and soil conditions and safeguards to natural resources (Kokate *et al*., 2012; Shukla and Behera, 2012; Palsaniya and Ahlawat, 2009; Rego *et al*., 2005; Vasuki, 2010; Rattan *et al.,* 2009).

Residual Effect

The residual effect of balanced fertilization was monitored in subsequent crops grown on above plots during *rabi,* 2011-12 and it was observed that application of B, Zn and S to groundnut had residual effect on succeeding wheat, barley, chickpea and mustard (Table 3). The mean yield of wheat was 3010 kg ha^{-1} when balanced nutrients were applied to the preceding groundnut crop. It was 231 kg higher compared to wheat yield (2779 kg ha^{-1}) obtained from the field where no B, Zn and S were applied to preceding groundnut. Similarly, average barley grain yield also increased by 337 kg due to residual effect of balanced nutrients applied to preceding groundnut. The mean chickpea yield under residual plots (1783 kg ha^{-1}) was 145 kg higher compared to yield obtained from control plots (1638 kg ha^{-1}). Likewise, average mustard yield under residual plots (1385 kg ha^{-1}) was 116 kg higher compared to yield obtained from control plots (1269 kg ha^{-1}). The grain yield of succeeding wheat, barley, chickpea and mustard increased by 8.3, 10, 8.8 and 9.2%, respectively when balanced nutrients were applied to the preceding groundnut crop compared to yield obtained under control. The Sustainability Index (SI) of residual effect of balanced fertilization in wheat, barley, gram and mustard was 0.76, 0.74, 0.76 and 0.83, respectively.

Table: 2
Groundnut yield with micro nutrients in participatory trials

Name of farmer	Pod yield (kg ha^{-1})		Yield increase (%)
	With Micronutrients (B, Zn) and S	Without micronutrients and S	
Shri Ram Dayal	1850	1450	27.6
Shri Atma Ram	1980	1660	19.3
Shri Arun Kumar	1790	1525	17.4
Shri Kallu Sahu	1900	1630	16.6
Shri Bahadur Singh	2020	1515	33.3
Shri Daya Ram	1660	1370	21.2
Shri Sharda Saran	1710	1370	24.8
Shri Ram Pal Singh	1800	1456	23.6
Shri Arvind Singh	1625	1420	14.4
Shri Puran Rai	1810	1600	13.1
Shri Jindel Singh	1720	1560	10.3
Srimati Kasturi Devi	1925	1690	13.9
Shri Vijay Singh	1930	1710	12.9
Shri Om Prakash	1695	1450	16.9
Shri Jagat Ram	1870	1690	10.7
Shri Tula Ram	1820	1695	7.4
Shri Bhajan Lal	1655	1575	5.1
Shri Roshan Singh	1880	1555	20.9
Shri Kali Charan	2120	1895	11.9
Shri Ashok Kumar	2070	1720	20.3
Range	1625-2120	1370-1895	5.1-33.3
Standard Error	31.4	30.5	-
Mean	1842	1577	16.8
Sustainability Index	0.80	-	-

Economic Gain

Besides harvesting more grain yield, farmers also benefited economically by spending only ₹ 1750 ha^{-1} for B, Zn and S over and above other nutrient inputs. The net economic gain due to direct application of B, Zn and S to chickpea and groundnut were ₹ 3024 and 7155 ha^{-1}, respectively (Fig. 3). The economic gain due to residual effect of B, Zn and S applied to previous crop was also recorded in succeeding mustard, wheat, barley and chickpea

Table: 3
Residual effect of micronutrients applied to groundnut on succeeding crops

Succeeding crop/ Farmers	Grain yield (kg ha^{-1})		Yield increase (%)
	With micronutrients (B, Zn) and S	Without micronutrients and S	
Wheat			
Shri Ram Dayal	3450	3200	7.8
Shri Atma Ram	2800	2710	3.3
Shri Arun Kumar	3190	2905	9.8
Shri Kallu Sahu	2600	2300	13.0
Mean	3010	2779	8.3
Standard Error	191.1	-	-
Sustainability Index	0.76	-	-
Barley			
Shri Bahadur Singh	3875	3590	7.9
Shri Daya Ram	3360	3010	11.6
Shri Sharda Saran	4450	4120	8.0
Shri Ram Pal Singh	3360	3000	12.0
Shri Arvind Singh	3470	3125	11.0
Shri Puran Rai	3690	3340	10.5
Mean	3701	3364	10.0
Standard Error	171	-	-
Sustainability Index	0.74	-	-
Gram			
Shri Jindel Singh	1680	1570	7.0
Smt. Kasturi Devi	1950	1800	8.3
Shri Vijay Singh	1785	1610	10.9
Shri Om Prakash	1590	1390	14.4
Shri Jagat Ram	1600	1550	3.2
Shri Tula Ram	2090	1910	9.4
Mean	1783	1638	8.8
Standard Error	82.4	-	-
Sustainability Index	0.76	-	-
Mustard			
Shri Bhajan Lal	1350	1230	9.8
Shri Roshan Singh	1210	1090	11.0
Shri Kali Charan	1480	1350	9.7
Shri Ashok Kumar	1500	1405	6.8
Mean	1385	1269	9.2
Standard Error	67.1	-	-
Sustainability Index	0.83	-	

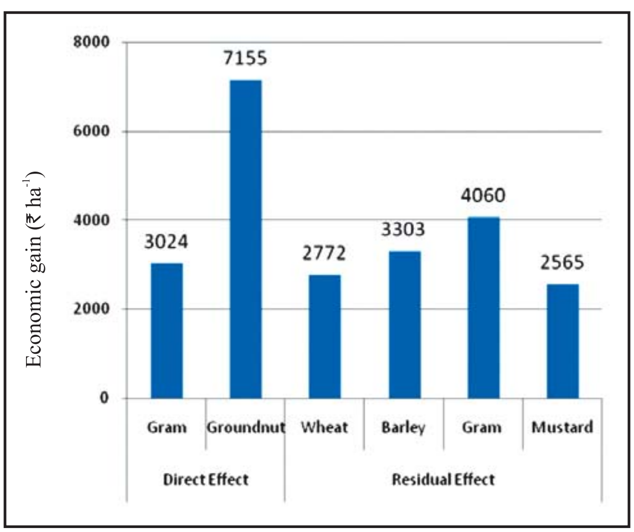

Fig.3. Net economic gain due to direct and residual effect of B, Zn and S application

to the tune of ₹ 2565, 2772, 3303 and 4060 ha^{-1}, respectively. In a similar study, Rego *et al.* (2005) also reported net economic gain of ₹ 8200 ha^{-1} for maize and ₹ 2900 ha^{-1} for pigeonpea in Mahbubnagar watersheds. Similarly, in Nalgonda watersheds, net economic gain for castor was ₹ 1600 ha^{-1} while that for Mung bean was ₹ 2700 ha^{-1}. In Kurnool, the net economic gain for groundnut was ₹ 6500 ha^{-1} while that for pigeonpea was 3200 ha^{-1} due to balanced fertilization. Balanced application of micronutrients with major nutrients to different crops showed similar response in watershed projects in other parts of the SAT in India. Participatory work at watershed projects in Vidisha, Guna and Dewas districts of Madhya Pradesh revealed 40 to 83% increase in groundnut grain yield with considerable residual effect on yield of succeeding chickpea and wheat (Rego *et al.,* 2005). Similarly, at Lalatora watershed (Vidisha, Madhya Pradesh), they further reported that combined application of B and S to soybean increased its grain yield by 26, 18 and 53% in 2000, 2001 and 2002, respectively over control (farmer input).

The residual effect of these micronutrients in the following wheat crop was in the range of 5 to 18%. Further, on average (the average of all on-farm trials on soybean-wheat cropping system), the soybean grain yield for combined application of B+S treatment was 1770 kg ha^{-1} while it was only 1400 kg ha^{-1} in control. Grain yield of the following wheat crop was 3700 kg ha^{-1} in treated plots while control plot yielded 2700 kg ha^{-1} of wheat grain. The net profit from soybean-wheat system was ₹ 26,450 ha^{-1} in treated plots compared to ₹ 17,760 ha^{-1} in control plot. A similar research work at Adarsha watershed (Andhra Pradesh) also revealed that application of B and S increased sorghum grain yield from 13 to 29% while increase in maize grain yield was 20 to 39% over control. ICRISAT while scalingup the watershed interventions for enhancing agricultural productivity in Andhra Pradesh during 2003 under APRLP selected total 50 watersheds and reported an increased response in yield of various crops to application of S, Zn and B along with N and P. The response obtained by combined application of B, Zn and S at farmer level and at optimum N and P level was (51 and 76% in maize, 41 and 61% in sorghum, 47 and 78% in groundnut, 41 and 61% in Mungbean, 71 and 90% in pigeonpea and 54 and 70% in castor, respectively (Rego *et al.,* 2005, 2007). Combined application of B and S with other nutrients to maize in Bundi watershed (Rajasthan) increased grain yield by 60% over control (Rego *et al.,* 2005). In other 279 trials conducted in Banswara, Jhalawar and Tonk districts of Rajasthan in maize, soybean, pearlmillet and groundnut crops during 2010, it was observed that combined application of Zn+B+S increased yield of these crops in range of 10 to 50% as compared to the farmers practice (Girish Chander *et al.,* 2011).

Spread of Micronutrient Use and Hurdles in Adoption

Investigations were made on spread of micronutrients and hurdles in adoption through structured Questionnaire Proforma and its outcome is summarized in Table 4. It was learnt that despite concerted efforts, spread and adoption of micronutrients (balanced fertilization) was not satisfactory. Although nearly 88% farmers were convinced by the impact of micronutrients, but only 9% farmers actually used them in *kharif* 2012. Nearly 76% farmers wanted to use micronutrients but only 28 tried to buy them. Availability and awareness found to be the major hurdles in spread of micronutrient use as 68% farmers mentioned that these are not easily available and 10% cited lack of knowledge regarding micronutrients. The per cent of farmers not convinced by the quality, cost and effectiveness of micronutrients was 8, 5 and 10%, respectively. Therefore, there exist a greater scope for micronutrient manufacturing and marketing companies to make available quality micronutrient fertilizers at affordable cost as 76% of the farmers surveyed wanted to use them. More farmers may be persuaded to adopt micronutrients through spreading awareness regarding effects of micronutrients on crop productivity.

Table: 4
Spread of micronutrient use and hurdles in adoption (2012)

Particulars	No. of farmers
Spread of micronutrient use (N=80)	
Farmers convinced by the impact of micronutrient use	70 (87.5)
Farmers wanted to use micronutrient	61(76.3)
Farmers tried to buy micronutrient	22 (27.5)
Farmers actually used micronutrient	7 (8.7)
Hurdles in adoption of micronutrients	
Availability	54 (67.5)
Quality of available micronutrient mixture	6 (7.5)
Cost	4 (5.0)
Lack of knowledge and awareness	8 (10.0)
Not effective	8 (10.0)

Figures in parenthesis indicate %

4. CONCLUSIONS

A widespread deficiency of S, Zn and B was observed and balanced application improved the yield of various crops in range of 13-17% in participatory entry point trials. Further, the residual effect of balanced fertilization increased the grain yield of succeeding crops by 8-10%. Nearly 88% farmers appreciated the impact of balanced fertilization, but only 9% farmers actually used them in succeeding season and availability of micronutrients was emerged as the major hurdle in up scaling. Therefore, researchers, extension personnel, policy-makers, fertilizer industry and dealers all have to contribute to make micronutrients available to farmers at affordable prices.

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