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Productivity Enhancement and Improved Livelihoods through Participatory Soil Fertility Management in Tribal Districts of Andhra Pradesh

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ABSTRACT : Under the National Agricultural Innovation Project (NAIP), three tribal-dominated districts (Adilabad, Khammam and Nalgonda) in Andhra Pradesh were selected to study the role of Site Specific Nutrient Management (SSNM) and balanced nutrition to enhancing income and livelihood security. By adopting a toposequence approach, 720 surface soil samples were collected from 39 villages with the participation of farmers. The soil sampling was based on stratified random sampling. Generally, it is believed that soils in the tribal region are rich in organic carbon and high in soil fertility because of relatively low intensity cropping. Contrary to this belief, the results of soil analyses showed that most of the soils are low to medium in organic carbon, low in available N and P, and low to high in available K. Among the secondary and micronutrients, S, B and Zn are the emerging nutritional constraints. By adopting SSNM and balanced nutrition approach, increase in yield ranged from 13 to 53% in cotton, 15 to 58% in chickpea, 18 to 44% in groundnut, 33 to 47% in green gram; and in vegetable crops, the increase in yield varied from 25 to 54% in tomato and 7-10% in Bhindi (Ladies finger) over the farmer's practice (FP). Net income and return per Re investment also increased by balanced nutrition. In cotton, net income obtained ranged between Rs. 30783 and 55533 ha^{-1} in Adilabad, Rs. 15,030 and 70,533 ha^{-1} in Khammam under balanced nutrient management. In other crops, the net return was Rs. 5564-14214 ha^{-1} in chickpea, Rs. 8380-13840 ha^{-1} in groundnut, Rs. 4207-8995 ha^{-1} in green gram, Rs. 47526-78329 ha^{-1} in tomato and Rs. 15570-38370 ha^{-1} in Bhindi under balanced nutrition. Mean value of return per Re investment was 2.97-3.05, 1.78, 1.60, 1.55, 2.09 1nd 1.78 in cotton, chickpea, groundnut, green gram, tomato and Bhindi, respectively under balanced nutrition.

Key words: Site Specific Nutrient Management, balanced nutrition, on-farm trials, livelihoods, tribal regions.

Over the past four decades, the crop management in India has been driven by an increasing use of external inputs. Fertilizer nutrients have played a major role in improving crop productivity. During the period 1969 to 2007, food grain production more than doubled from about 98 million t (M t) to a record 230 Mt in 2007-08, while the fertilizer nutrient use increased by nearly 12 times from 1.95 M t to more than 23 Mt in 2007-08 (Rao 2009). Notwithstanding these impressive developments, food grain demand is estimated to increase to about 300 Mt by 2025 for which the country would require 45 Mt of nutrients (ICAR 2008). With almost no opportunity to increase the area under cultivation over 141 M ha, much of the desired increase in food grain production has to be attained through yield enhancement in per unit area or productivity enhancement. To sustain production demands, the productivity of major crops has to increase annually by 3.0 to 7.5% (NAAS 2006). Much of this has to be met by increasing genetic potential and improved production efficiency of the resources and inputs like water and nutrients. In addition, the growing concern about poor soil health and declining factor productivity or nutrient use efficiency has raised concern on the productive capacity of agricultural systems in India. For example, research on farmers' fields has revealed that there is no compelling evidence for significant increases in fertilizer N efficiency during the past 30 years (Dobermann and Cassman 2002). The average plant recovery efficiency of fertilizer N is still only about 30% (Dobermann 2000). Major factors contributing to the low and declining crop responses to fertilizer nutrients are: (a) continuous nutrient mining due to imbalanced nutrient use, which is leading to depletion of major, secondary, and micro nutrients including P, K, S, Zn, Mn, Fe and B, and (b) mismanagement of irrigation systems, leading to serious soil quality degradation. Furthermore, low efficiency of resources and fertilizer inputs has impacted the production costs with serious environmental consequences. Recent research (Dobermann *et al.* 2002, Wang *et al.* 2001) has demonstrated limitations of the blanket fertilizer recommendations practiced across Asia. Cassman *et al.* (1996) observed that the indigenous N supplying capacity of soils varied among fields and seasons, and was not related to soil organic matter content. On-farm research has clearly demonstrated the existence of large field variability in soil nutrient supply, nutrient use efficiency and crop responses. Thus, it was hypothesized that future gains in productivity and input use efficiency will require soil and crop management technologies that are knowledge-intensive and are tailored to specific characteristics of individual farms or fields to manage the variability among and within fields (Tiwari 2007).

Rainfed farming comprises about 80 per cent area under coarse cereals, 85% of pulses, 72% of oil seeds and 64% of cotton, besides supporting two thirds of livestock population. Adilabad, Nalgonda and Khammam are tribal-dominated districts of Andhra Pradesh; in these areas soils are low to medium in organic carbon, and are coarse to medium in texture, and low in biological activity. The modest quantity of organic and crop residues added are rapidly oxidized due to high temperature prevailing in the arid and semi-arid regions, allowing little humification of the added organic matter. The soils of the rainfed regions are not only thirsty but are also hungry. Soil erosion with depletion of nutrients under continuous cropping without adequate additions of nutrients and organic matter over the years has resulted in the degradation of soils. Wide-spread deficiencies of macro, micro and secondary nutrients have been reported in the rainfed areas (Rego *et al.* 2007, Srinivasarao *et al.* 2008), and these must be overcome through balanced nutrition of crops. While much attention has been paid to correcting S and micronutrient deficiencies in irrigated systems, little efforts are made to diagnose secondary and micronutrients deficiencies in the rainfed regions in India. Present study examines the extent of nutritional constraints and the scope of Site Specific Nutrient Management (SSNM) approach on productivity enhancement and livelihood improvement in tribal dominated area of Andhra Pradesh.

Materials and Methods

Study area

The target area for this study comprised of three backward and tribal dominated districts of Andhra Pradesh covered under the Component 3 sub project "Sustainable rural livelihoods through enhanced farming systems productivity and efficient support systems in rainfed areas" under NAIP, which is being implemented by a consortium led by Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad since September 2007. It aims at improving the livelihoods of the rural poor by improving the overall systems productivity by following good agricultural practices, better natural resource management and addressing the issues of profitability and sustainability through efficient institutional and support systems. The project sites are selected based on the criteria of dominance of rainfed farming, SC and ST population, low household income and poor infrastructure. General description of the study sites are given in Table 1.

Participatory soil sampling

Soil samples from 720 farmers' fields covering 39 villages of the three districts were collected during 2009 with farmer participation in soil sampling. After conducting farmers' meeting in each village and depending upon soil type, crop, slope and management, about 30 per cent of farmers' fields were selected for sampling using stratified random methodology. The identified farmers were made into groups for demonstration of soil sampling procedure. Collected soil samples were labeled with cluster name, village name and farmer's name. In most of the clusters, village sarpanch or village head was involved in participatory soil sampling. Collected soil samples were analyzed in the soil chemistry laboratory at the CRIDA.

Soils analysis

The soil pH was measured by glass electrode using a soil to water ratio of 1:2; electrical conductivity (EC) was determined by an EC meter using a soil to water ratio of 1:2. Organic carbon was determined using the Walkley-Black method (Nelson and Sommers 1996). Available N was determined by alkaline permanganate method (Subbiah and Asija 1956). Available P was determined by Olsen (Olsen and Sommers 1982) and Bray methods, respectively in neutral to alkaline and acidic soils, respectively, K by neutral normal ammonium acetate method (Hanway and Heidel 1952), Available S was measured using 0.15% calcium chloride ($CaCl_2$) solution as an extractant (Tabatabai 1996), available micronutrients (Zn, Fe, Cu and Mn) were extracted by DTPA reagent (Lindsay and Norvell 1978) and available B was extracted by hot water (Keren 1996).

On farm trials

During 2009-10, a total of 89 on-farm trials were conducted with different test crops in Adilabad (*kharif* cotton and *rabi* chickpea), Khammam (cotton) and in Nalgonda (groundnut, green gram and vegetable crops like tomato and Bhindi) districts with the objective to demonstrate the comparative evaluation of SSNM and balanced nutrition and farmers practice. Crops were grown on selected farmers' fields with known fertility status and SSNM based nutrient application. Balanced nutrition was compared with the farmers' practice in an area of half acre in each of the farmers' fields. The balanced nutrition included a recommended dose of fertilizers (90 kg N and 50 kg P_2O_5 for cotton, 20 kg N and 40 kg P_2O_5 for chickpea, groundnut and green gram, 150 kg N and 80 kg P_2O_5 for tomato and 120 kg N and 60 kg P_2O_5 for Bhindi) along with basal application of micro-nutrient mixture of 2.5 kg agribor/5 kg borax (0.5 kg B ha^{-1}), 50 kg zinc sulphate (10 kg Zn ha^{-1}) and

Table 1 : Details of study sites/villages selected in the target districts

District	Villages	No of villages	No. of Households	Area (ha)	Characteristics of the cluster	Soil	Type Crops
Adilabad	Seethagondi, Garkampet, Arkapally, Old Somwarpet, Pedamalkapur, Chinamalkapur, Kotwalguda, New Somwarpet	8+2*	575	1296	High tribal population (70%) and close to forests, very low productivity and technology adoption. VSS are active.	Black	Cotton+ pigeonpea
Nalgonda	New banjara hills, Jamal kunta thanda, Seetamma thanda, Yellapa kunta thanda, Chinagore kunta thanda, Pedagore kunta thanda, Peda seetharam thanda, China Seetharam thanda, Lalsingh thanda,	9+9	621	500	Highly drought prone area, off season employment and high migration rates, small hamlets/ tandas with more than 80% tribes.	Red and black	Groundnut, pigeonpea, greengram, sorghum, vegetables
Khammam	Bheemavaram, Koremvarigumpu, Kurvapally Kothuru, Mamillavai, Ramavaram, Thummalacheruvu, Venkatapuram	7+4	650	1000	High tribal population, assigned and forest lands, poor communication and market facilities, high indebtedness.	Red and black	Cotton, sorghum

*Extended villages

200 kg gypsum/elemental sulphur (30 kg S ha^{-1}) per hectare. Farmer's practice in each trial was documented, which included suboptimal dose of N and P. Entire dose of N and P was applied as basal. Besides other crop management practices like weeding and pest and disease control measures were followed. The data on crop yield and economic returns were analyzed considering farmers as replications using one way ANOVA with randomized blocks on GenStat.

Results and Discussion

Fertility status of the soils of target districts

Soil reaction, electrical conductivity and fertility status of soils of different villages in three clusters are presented in Table 2. Soils of Thummalacheruvu, Dupahad, and Seethagondi showed pH ranging from acidic to the alkaline range. However, mean EC of soil samples in all clusters was normal. Organic carbon content of different clusters varied widely among villages. Mean values of organic carbon ranged from 0.46% in Dupahad cluster to 0.70% in Tummalacheruvu cluster. While characterizing 21 profiles representing major rainfed production systems of India, Srinivasarao *et al.* (2007) reported that most of the profiles were low in organic carbon. Organic matter is the major source of N in soils and therefore rainfed soils which are poor in organic matter are deficient in N. Low levels of soil N is attributed primarily to inappropriate management options, hot tropical climate and cropping systems prevalent in the region. 61-76% farmer's fields are deficient in available N. Available P and K deficiency ranges from 29-60% and 2-14% farmers' field, respectively. Wide variation in available P status of soils was reported among production systems as well as soil types (Srinivasarao *et al.* 2007). Swindale (1982) stated that P deficiency considerably constraints productivity of rainfed crops. In the semi-arid tropics, the deficiency was noticed in coarse textured soils, some red soils and in soils, which produced high crop yields without K application for a long period (Srinivasarao *et al.* 2002). Continuous cotton, sorghum, maize and groundnut crops on these soils result in further aggravation of K deficiency. Black soils (Vertisols and Vertic intergrades) were found to be sufficient in available K because of higher clay content and nature of clay (Srinivasarao *et al.* 2001). Potassium status of different agro ecological sub-regions of India (Subba Rao and Srinivasarao 1996) indicated that available K of rainfed regions varied from low to high, depending

Table 2 : Cluster-wise fertility status in farmer's fields of tribal districts of Andhra Pradesh.

Name of the village		pH	EC (dS/m)	OC (%)	Av.N	Av.P	Av.K	Av.S	Av.Zn	Fe	Cu	Mn	Av.B
					(kg/ha)				(mg/kg)				
Adilabad	Range	6.2-8.8	0.08-2.66	0.27-1.33	122-355	6-109.3	46-549	2.0-142.2	0.22-2.90	0.96-12.52	0.56-1.70	1.44-22.1	0.10-0.74
	Mean	8.1	0.29	0.62	210	15.5	205	12.2	0.62	5.76	1.1	6.89	0.34
	% deficient farmers' field			27	63	60	2	76	74	4	3	-	62
Nalgonda (420)	Range	5.3-8.8	0.07-1.60	0.14-1.13	136-297	0.2-50.4	21-346	2.1-140.3	0.22-6.58	0.99-13.622	0.47-1.60	1.47-20.30	0.04-1.20
	Mean	7.4	0.29	0.46	192	9.0	89	17.0	1.02	5.92	1.01	6.50	0.34
	% deficient farmers' field			68	76	29	14	61	51	3	9	2	56
Khammam (161)	Range	4.8-8.6	0.03-0.82	0.32-1.50	157-343	0.2-57.8	31-856	3.6-71.9	0.28-6.80	0.96-10.82	0.59-11.8	1.59-24.33	0.12-1.22
	Mean	6.7	0.18	0.70	204	8.5	180	10.6	1.09	4.99	1.19	7.30	0.39
	% deficient farmers' field			25	61	60	2	67	45	5	6	2	67

Critical limits considered for low content : OC<0.5, Av. N<280 kg ha^{-1}, Av. P<12 kg ha^{-1}, Av. K<120 kg ha^{-1}, Av. S<22.4 kg ha^{-1}, Zn<0.75 mg kg^{-1}, Cu<0.5 mg kg^{-1}, Fe<6 mg kg^{-1}, Mn<1.0 mg kg^{-1}, B<0.58 mg kg^{-1}.

upon soil type, parent material, texture, mineralogy and management practices. S, B and Zn were also deficient in most of the farmers' fields. Like nitrogen, the content and availability of sulphur are largely determined by the organic matter level of the soils. Sulphur is reported to be deficient in a vast majority of the dryland soils (Srinivasarao *et al.* 2003).

Dryland soils are known to be deficient in several micronutrients also. While organic matter levels and the soil mineralogy determine the micronutrient content of soils, their retention, release and availability are controlled by clay type, content, pH and lime content (Takkar 1996). Among nutrients, B deficiency was emerging problem in the Andhra Pradesh soils. While explaining experiences from participatory watershed management under semi-arid India, Rego *et al.* (2007) reported that B deficiency in soils of several states (Andhra Pradesh, Karnataka, Tamil Nadu, Madhya Pradesh, Rajasthan), up to 98 per cent tested soils and substantial response to B application was found.

Yield advantage by implementing balanced nutrition

In Adilabad district, the benefits of balanced nutrition were much higher. This could be due to continuous cotton based system with a mean yield of 2.37 t ha^{-1} of seed cotton (SSNM) compared to mean yield of 1.66 t ha^{-1} (FP) registering 43.1% yield increase (Fig. 1), and low levels of fertilizer application to cotton, chickpea or cotton-pigeonpea intercropping system resulted in mining of soil nutrients. Though, these villages are with 100 percent tribal population, the cotton has been grown

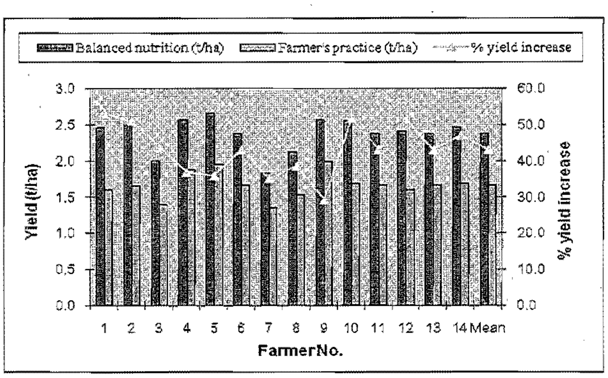

Fig. 1: Effects of balanced fertilization on cotton yield in farmers' fields of Seethagondi cluster, Adilabad district, Andhra Pradesh, *Kharif* 2009-2010. (CD (P=0.05) 0.19).

for the last 10-15 years without much nutrient inputs. This is one of the reasons for higher cotton response to balanced nutrition. Soils in Tummalacheruvu cluster in Khammam district are fine textured red soils with multi-nutrient deficiencies. Cotton yields (Bt) ranged from 0.9 to 2.5 t ha^{-1} in farmers' practice with an average yield of 1.9 t ha^{-1}, and yield levels improved to the range of 1.3 to 3.2 t ha^{-1} in SSNM with an average yield of 2.4 t ha^{-1} showing 13.6-53.0% increase in yield (Fig. 2). As soils are deep and fine textured with high soil moisture storage capacity resulted in additional benefits due to SSNM. Hybrid cottons are exhaustive crops requiring heavy nutrient supplementation. Nutrient

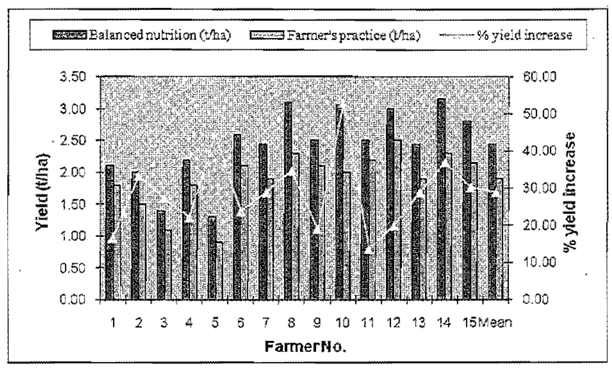

Fig. 2: Effects of balanced fertilization on Bt-cotton yield in farmer's field of T. Cheruvu cluster, Khammam district, Andhra Pradesh, *Kharif* 2009-2010. (CD (P=0.05) 0.23).

requirement however, varies with cultivars, growing conditions and management practices. Nutrition affects cotton yield to a greater extent than its quality. Fruiting efficiency (ratio of weight of bolls to dry weight of stems) is one of the important yield parameters influenced by nutrients. Hybrid cotton has been found to use 5.81 kg N, 1.97 kg P_2O_5 and 6.59 kg K_2O per quintal of seed cotton (Pundarikakshudu 1985). Prasad and Prasad (1998) reported that maximum seed cotton yield (2150 and 3500 kg ha^{-1}) was recorded when the crop was fertilized with 90 kg N + 60 kg P_2O_5 + 30 kg K_2O + 25 kg $ZnSO_4$. Doberman *et al.* (2000) reported that SSNM improved the cotton yield by 10-20 per cent under temperate condition.

Among the *rabi* crops, chickpea (variety JG-11) showed significant response to SSNM in Seethagondi cluster of Adilabad district. Mean seed yield increased from

0.89 to 1.21 t ha^{-1} due to balanced nutrition registering 35.1% yield increase (Fig. 3). Being a pulse crop, its S requirement is met from added sulphur in the form of gypsum besides application of other nutrients. However, the variation in the crop response to balanced nutrition was wide among farmers' fields. The improvement in chickpea yield with balanced nutrition was from 15 to 58% over farmer's practice. This indicates that with improved varieties of chickpea (JG-11), a well nourished crop can yield up to 1.5 t ha^{-1} on deep black soils of Adilabad district. In other crops like groundnut and green gram in Dupahad cluster of Nalgonda district, mean seed/pod yield increased from 1.08 to 1.41 t ha^{-1} and from 0.54 t ha^{-1} to 0.75 t ha^{-1}, respectively due to balanced nutrition registering 31.1 and 39.6% yield increase (Fig. 4 & 5). Similarly, greengram and groundnut response also varied from 33 % to 47% and 18% to 44%, respectively. Thiyagarajan *et al.* (2003) reported that the use of sulphur and micronutrients (Zn, B, Mo and Fe) improved productivity of pulse crops considerably. Balanced nutrition is indispensable for achieving higher productivity. Sachdev *et al.* (1992) obtained increased grain yield and harvest index of chickpea due to balanced fertilization. Shinde and Mane (1996) reported that balanced application of fertilizers based on soil testing improved the yield of chickpea by 47 percent over control. Tomar *et al.* (2010) reported that improved production technology which includes balanced nutrition increased the yield of chickpea to 19.65 q/ha which was 72 % higher than that obtained with farmers practice of 11.44 q/ha. Srinivasarao *et al.* (2008) reported 2.18 t ha^{-1} chickpea yield through S, B and Zn application compared to farmer's practice, which registered only 1.33 t ha^{-1} in Guna district of Madhya Pradesh. He also reported 55% pod yield advantage in groundnut through balanced nutrition with S, B and Zn compared to farmers practice. Yield increase in chickpea in response to application of recommended fertilizer was also reported by Tamboli *et al.* (1996) and Ramakrishna *et al.* (2005).

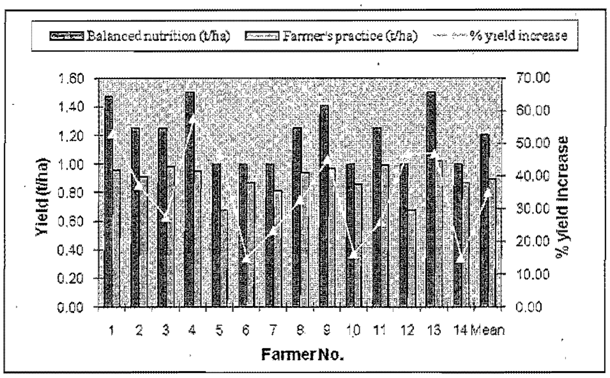

Fig. 3: Effects of balanced fertilization on chickpea (var. JG-11) yield in farmers' fields of Seethagondi cluster, Adilabad district, Andhra Pradesh. (2009-2010). (CD (P=0.05) 0.24).

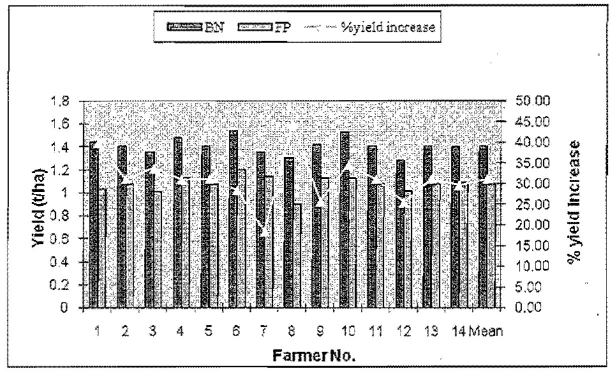

Fig. 4: Effects of balanced fertilization on groundnut yield in farmers' fields of Dupahad cluster, Nalgonda district, Andhra Pradesh, 2009-2010. (CD (P=0.05) 0.08).

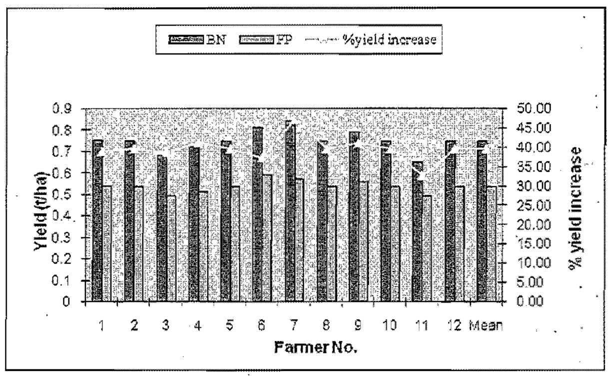

Fig. 5: Effects of balanced fertilization on green gram yield in farmers' fields of Dupahad cluster, Nalgonda district, Andhra Pradesh, 2009-2010. (CD (P=0.05) 0.07)

Among vegetable crops, tomato and Bhindi mean yield increased from 21.6 t ha^{-1} to 30.4 t ha^{-1} and 8.7 t ha^{-1} to 11.6 t ha^{-1} registering 41% and 33% increase in yield, respectively in Nalgonda district (Fig. 6a & b). Srinivasarao *et al.* (2010) reported increase in fruit yield in ridge gourd and bitter gourd, chilli, brinjal and tomato through fertilization with recommended dose of NPK along with S, B and Zn compared to farmers practice in Haveri and Dharwad districts of Karnataka. However,

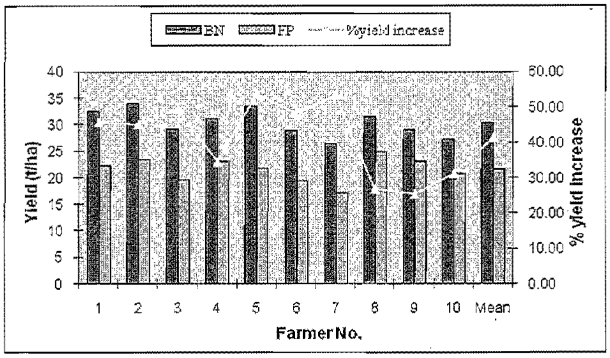

Fig. 6: Effects of balanced fertilization on tomato yield in farmers' fields of Dupahad cluster, Nalgonda district, Andhra Pradesh, 2009-2010. (CD (P=0.05) 0.9).

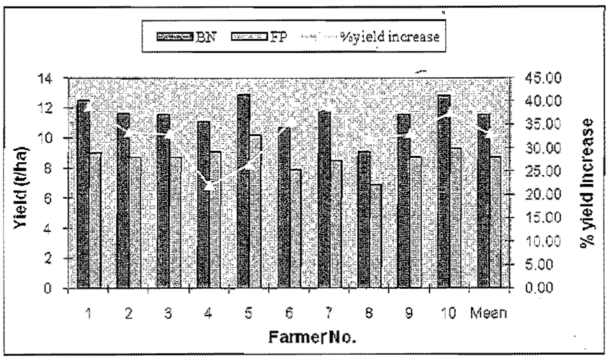

Fig. 7: Effects of balanced fertilization on Bhindi yield in farmers' fields of Dupahad cluster, Nalgonda district, Andhra Pradesh, 2009-2010. (CD (P=0.05) 0.4).

it was found that the magnitude of yield increase due to balanced nutrient management was greater in tomato compared to other vegetables. The study showed significant response of vegetables to micronutrient application similar to that shown by field crops. In Kolar and Chikaballapur districts of Karnataka, tomato yield increase ranged from 16.0 to 20.4 t ha^{-1} and 27.0 to 30.1 t ha^{-1}, respectively with balanced nutrition including micro nutrients.

Impact of balanced nutrition on farm income

The economic viability of balanced nutrition over the farmers' practice was calculated depending on prevailing prices of input and output costs. The additional cost (Table 3) incurred in the balanced nutrition as compared to farmers' practice was mainly due to micro and secondary nutrients and additional N and P. Net income and return per Re investment improved substantially through balanced nutrition. In cotton net income obtained from Rs.30783-55533 ha^{-1} in Adilabad, Rs. 15,030-70,533 ha^{-1} in Khammam through balanced nutrition. Similarly in other crops, net returns obtained Rs. 5564-14214 ha^{-1} in chickpea, Rs. 8380-13840 ha^{-1} in groundnut, Rs. 4207-8995 ha^{-1} in greengram, Rs. 47526-78329 ha^{-1} in tomato and Rs. 15570-38370 ha^{-1} in Bhendi through balanced nutrition in comparison Rs. 19213-38113 ha^{-1} in cotton at Adilabad, Rs. 5713-53713 ha^{-1} in cotton at Khammam, Rs. 2228-8110 ha^{-1} in chickpea, Rs. 2600-8900 ha^{-1} in groundnut, Rs. 2375-4895 ha^{-1} in greengram, Rs. 12926-43726 ha^{-1} in tomato and Rs. 4570-24370 ha^{-1} in Bhendi through farmer's practice. Mean value of return per Re investment was 2.97-3.05, 1.78, 1.60, 1.55, 2.09 1nd 1.78 in cotton, chickpea, groundnut, greengram, tomato and Bhendi respectively through balanced nutrition compared to 2.34-2.68, 1.62, 1.39, 1.35, 1.55 and 1.42 in farmer's practice. Shinde and Mane (1996) reported that the balanced application of fertilizers based on soil testing improved the monetary returns by Rs 7676 ha^{-1} over control. Srinivasarao *et al.* (2008) reported increase of net return from Rs. 23180 ha^{-1} to Rs. 12440 ha^{-1} and BC ratio from 2.18 to 2.63 in chickpea through balanced nutrition compared to farmers practice in Guna district of Madhya Pradesh. Tomar *et al.* (2010) reported that balanced nutrition increased mean net return of Rs. 24611 ha^{-1} with a benefit cost ratio 2.99 as compared to local practice (Rs 11820 ha^{-1} benefit cot ratio 2.58) in chickpea. Srinivasarao *et al.* (2010) reported that higher B:C ratio in case of tomato (11.4) followed by green chilies (4.26) bitter gourd (2.71) and ridge gourd (1.87). Among crops tomato responded well to micronutrient application resulting an additional net returns of Rs. 34,800 ha^{-1} followed by green chillies (Rs. 13000 ha^{-1}) and brinjal (Rs. 12770 ha^{-1}) in Dharwad and Haveri district of Karnataka. This additional income could substantially benefit the resource poor farmers and improve their livelihoods in the low fertile tribal dominated districts of Andhra Pradesh.

Impact of SSNM on livelihood

Increasing crop productivity by application of improved technologies was one of the strategies for enhancing the livelihood security of the rural poor in the project. Thus a systematic effort was made to assess the native nutrient status of soil and supplement the same with application of appropriate nutrients in required quantity.

Table 3 : Economic advantage due to Site Specific Nutrient Management and balanced nutrition followed in different crops in target clusters of tribal dominated districts of Andhra Pradesh.

District/ Cluster trials trials	Crop/ No. of	Cost of (Rs./ha)		Net return cultivation (Rs./ha)		Return per Rupee investment	
		BN	FP	BN	FP	BN	FP
Adilabad (Seethagondi)	Cotton (14)*	23967	21287 (47174)**	30783-55533 (28540)	19213-38113 (2.97)***	2.28-3.32	1.90-2.79 (2.34)
	Chickpea (14)	11736	9536	5564-14214 (9123)	2228-8110 (5898)	1.47-2.21 (1.78)	1.23-1.85 (1.62)
Khammam (Tummalacheruvu)	Cotton (15)	23967	21287	15033-70533 (49210)	5713-53713 (35828)	1.63-3.94 (3.05)	1.27-3.52 (2.68)
Nalgonda (Dupahad)	Groundnut (14)	18500	16300	8380-13840 (11068)	2600-8900 (6317)	1.45-1.75 (1.60)	1.16-1.55 (1.39)
	Greengram (12)	12173	9973	4207-8995 (6691)	2375-4895 (3527)	1.35-1.74 (1.55)	1.24-1.49 (1.35)
	Tomato (10)	58074	55874	47526-78326 (63486)	12926-43726 (30526)	1.82-2.35 (2.09)	1.23-1.78 (1.55)
	Bhendi (10)	39030	36830	15570-38370 (30345)	4570-24370 (15370)	1.40-1.98 (1.78)	1.12-1.66 (1.42)

BN= Balanced nutrition, FP= Farmer's practice, *No. of trials, ** & *** Values in parentheses indicate mean values

Enhancing crop productivity and household income has been adopted by the project as a short term measure towards improving rural livelihoods. It was observed in many cases in the project area that the additional income generated due to higher productivity and profitability was mostly ploughed back into farming as additional capital. Increased vegetable productivity enhanced cash flow in the family in short intervals. The families that participated in SSNM trials have shown higher consumption of vegetables at household level leading to better nutritional security as well.

Table 4 : Impact of SSNM implementation on household vegetable consumption in 3 tribal districtss

Weekly consumption of vegetables for household* purpose (g/day)	SSNM participant farmer	Check farmer (without SSNM)
Adilabad	350	200
Nalgonda	480	210
Khammam	450	350

*Average family size of 5 members

Many farmers, who realized higher profits due to better nutrient management, used their additional income for improving housing, buying animals, educating children, meeting social obligation etc. Pelli Venkanna of Jaffergudem says "From the additional profit I got from my cotton SSNM field, I spent Rs. 22000/- to plaster my house with cement," while Korra Harishehandra of the same cluster bought a sheep unit spending Rs. 13500/-. A relatively well to do farmer Buke Balu invested his profit to fund his son's education (B.Tech).

In Adilabad, D. Ratan of Seethagondi Cluster took up SSNM in chickpea and realized 30% higher income compared to other farmers. He made use of this money for purchasing Bt cotton seeds from a reputed company. He said "like previous years I did not have to compromise with seed quality. Since I had extra money (Rs. 12000/-) I could go for the best in the market."

Though the above anecdotes narrated above give a summary of the livelihood impacts of the SSNM interventions, they do not provide a total picture of all the farmers who adopted SSNM. However, the livelihood impacts which can be diverse and varied can only be captured through anecdotal evidence and qualitative data.

In Dupahad cluster of Nalgonda the impact of SSNM was observed mainly in vegetables like tomatoes, Bhendi, leafy vegetables like palak and flower crops such as marigold. Though these did not translate in large gains like in the case of cotton, nevertheless the additional income contributed to purchasing of household articles, better clothing and additional investment in purchasing better quality inputs for agriculture.

Conclusions

The general belief that soils in the tribal regions are rich in organic carbon and fertility status as a result of less intensive cropping with low yield, was found to be untrue. The tribal regions are intensively cultivated for the last two decades without much input with highly exhaustive crops like cotton and vegetables. Thus, soils showed multiple nutrient deficiencies. Addition of deficient nutrients increased yield and benefits to farmers in a spectacular manner. By adopting SSNM and balanced nutrition approach over the farmer's practice, yield levels were improved from 13 to 53% in cotton, 15-58% in chickpea, 18-44% in groundnut, 33-47% in green gram; and in vegetable crops from 25 to54% in tomato and 7-10% in Bhindi. Net income and return per rupee investment also were improved substantially through balanced nutrition. The results from the current study clearly bring out the potential of SSNM and balanced nutrition in enhancing household income of tribal farmers.

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