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Effect of Balanced Nutrition on Yield and Economics of Vegetable Crop in Participatory Watersheds in Karnataka

Effect of balanced nutrition was studied on the production of various vegetable crops including ridge gourd, bitter gourd, green chillies, brinjal, tomato, potato and onion in watersheds of several districts of Karnataka. Results of soil test analysis showed that the extent of sulphur, zinc and boron deficiency was up to 90%, besides they were low in nitrogen and low to medium in available P. Yield benefits in different vegetable crops due to balanced nutrition in Dharwad and Haveri districts varied from 16% to 52%. The maximum benefit: cost ratio was found in case of tomato (11.4:1). Similarly, in Kolar, Tumkur and Chitradurga districts, the tomato, potato, capsicum and onion yields improved substantially due to balanced application of deficient nutrients to soil as well as foliar spray.

CH. SRINIVASARAO
Central Research Institute for Dryland Agriculture, Santoshnagar, Hyderabad, 500 059, Andhra Pradesh
S. P. WANI
K. L. SAHRAWAT
K. KRISHNAPPA
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh
and
B. K. RAJASEKHARA RAO
Deptt. of Agriculture
University of Technology of PMB
Lae 411Morobe Province
Papua New Guinea

THE SOILS OF THE RAINFED AREAS ARE not only thirsty but are also hungry. Soil erosion along with mining of nutrients by continuous cropping, without adequate additions of nutrients, have impoverished the soils over the years. Wide-spread deficiency of macro, micro and secondary nutrients have been reported for rainfed areas (8,9,12); which must be overcome through integrated nutrient management to achieve balanced nutrition of crops to enhance productivity in a sustainable manner to meet the current and future food needs of the growing populations. Growth in agricultural productivity directly accounts for a disproportionately large share of economic growth and poverty reduction in a range of developing countries. Agriculture-led development with scientific knowledge to achieve food security and poverty reduction is feasible through upgrading rainfed agriculture by adopting holistic systems' watershed-based management approach with diversification of systems using high-value crops like vegetables and crop-livestock systems with increased water use efficiency and increased incomes.

Sulphur and micronutrient deficiencies have been reported in intensive, irrigated production systems globally and in Indian soils these deficiencies are reported as the main causes for yield plateau or declining yield levels (13 & 14). While, much attention has been paid to correcting S and micronutrient deficiencies in irrigated systems (12), little attention has been devoted to diagnose micronutrient deficiencies in the rainfed systems of the semi arid tropic (SAT) regions in India. It is well recognized that productivity of SAT soils is low due to water shortage. However, apart from water shortages, low soil fertility is also constraint for crop productivity in the SAT regions (8). Moreover, due to low crop productivity in the rainfed regions, it is assumed that mining of secondary and micronutrients is much less as compared to irrigated agriculture (8). In the SAT regions, higher productivity levels are achieved when the soil and water conservation practices are implemented along with nutrient management. The on-going farmer-participatory integrated watershed management programmes at ICRISAT provided the opportunity to implement nutrient management along with soil and water conservation practices in farmers' fields in the Indian semi-arid tropics. The experiences from several watersheds in different states revealed that extent of micronutrient deficiencies particularly zinc and boron along with sulphur were widespread and large scale yield benefits were recorded with the application of these nutrients along with N and P in case of field crops (12). However, effects of micro and secondary nutrients on vegetable crops in these regions were studied so far. In the present study, similar experiences in other watersheds Karnataka are presented by reporting on the extent of Zn, B and S deficiencies in farmers' fields, response of vegetable crops to the applications of S and micronutrients and the economics of balanced nutrition.

MATERIALS AND METHODS

Watershed Locations and Site Description

Benchmark watersheds in the districts of Dharwad, Haveri, Kolar, Tumkur and Chitradurga (Karnataka), were the test sites for studying the extent of nutrient deficiencies (**Table 1**). Most of these watersheds are about 500 ha in area (micro-watersheds) and number of farmers cultivating the arable land in each watershed varied across the watersheds. Hot summer and mild winter characterize these watersheds located in the semi-arid agro-ecological sub-regions of southern India. The experimental sites receive low to high erratic annual rainfall.

Table 1 – Extractable (available) Zn, B and S status of soil in farmers' fields in different watersheds of Karnataka

State/Location	No of farmers' fields	Zn(μg g⁻¹)		B(μg g⁻¹)		S(μg g⁻¹)	
		Min.	Max.	Min.	Max.	Min.	Max.
Dharwad(% deficient fields)	135	0.28	4.72	0.12	2.44	1.80	118.2
		(34)		(54)		(83)	
Haveri(% deficient fields)	217	0.20	2.32	0.08	1.58	1.80	60.70
		(79)		(63)		(81)	
Kolar(% deficient fields)	408	0.06	5.50	0.04	1.44	0.50	155.8
		(64)		(90)		(87)	
Tumkur(% deficient fields)	269	0.14	2.34	0.06	0.98	1.10	59.6
		(88)		(96)		(93)	
Chitradurga(% deficient fields)	231	0.08	3.40	0.04	4.08	1.20	601.4
		(93)		(75)		(82)	

* Percent deficient

Processed soil samples were analyzed in the ICRISAT analytical services laboratory. The soil pH was measured by a 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 C was determined using the Walkley-Black method (7). Available S was measured using 0.15% calcium chloride ($CaCl_2$) solution as an extractant, available Zn was extracted by DTPA reagent (5) and available B was extracted by hot water (4).

On-farm Trials

For response studies in vegetable crops, we conducted a number of trials in the five districts of Karnataka during 2006-2007. Different nutrient management trials included response of vegetables to micronutrients and sulphur. For various trials, control based on farmers' nutrient inputs mainly N and P (termed as FP) and application of nutrient amendments viz. 50 kg zinc sulphate (10 kg Zn ha^{-1}), 5 kg borax (0.5 kg B ha^{-1}) and 200 kg gypsum (30 kg S ha^{-1}) were included along with 150 kg urea and 75 kg DAP ha^{-1}. These nutrients were broadcast uniformly on the plot before the final land preparation. For harvesting the vegetable crops, economic yields (fresh weight) were collected from three spots in each treatment. For each spot, harvested area was 4 m^2. Thus in each trial, vegetables covering a total area of about 12 m^2 was harvested and the harvested yields were pooled. Based on cost of cultivation and net incomes, economic analysis was carried out.

RESULTS AND DISCUSSION

Extent of Nutrient Deficiencies in Karnataka Watersheds

Most of the watersheds studied are about 500 ha (micro watershed) in area and number of farmers cultivating the arable land varied across the watersheds. To have an efficient, cost-effective and representative sampling strategy, a stratified random sampling was developed for each watershed. Processed soil samples were used for analysis and sufficiency and deficiency of particular nutrient was done based on the following standard critical limits (9). The soils of the sites are mostly Vertisols and Alfisols and the soil texture varied from sandy loam to clay. In general, the soils were low in fertility, especially organic carbon (<0.5%) and available nitrogen (<280 kg ha^{-1}) and low to medium in available P. The inputs of plant nutrient through external sources and organic matter additions are very low and are the cause of low fertility and low organic carbon status. A total of 1260 farmers' fields were sampled from different watersheds in five districts of Karnataka. Extractable (available) Zn, B and S status of soil is presented in **Table 1**. In Dharwad district, out of 135 farmers fields (black soils), 34 fields were Zn deficient, 54 B deficient and 83 S deficient. In Haveri district, out of 217 farmers fields, the extent of Zn, B and S deficiency was 79, 63 and 81 per cent, respectively. In Kolar district (408 farmers' fields), the extent of Zn, B and S deficiency was 64, 90 and 87 per cent, respectively. Similarly, in Tumkur district (269 farmers' fields), 88, 96 and 93 per cent fields were deficient in Zn, B and S, respectively. In case of Chitradurga (231 farmers fields), the deficiencies were at 93, 75 and 82 per cent in Zn, B and S respectively. The extensive deficiency of Zn, B and S was due to poor organic carbon status of soils (11) and depletion under continuous cropping without application of these plant nutrients (9, 12).

Balanced Nutrition in Vegetables in Dharwad and Haveri Districts of Karnataka

The results revealed that application of 150 kg urea, 75 kg DAP, 200 kg gypsum, 5 kg borax and 50 kg $ZnSO_4$ ha^{-1} has increased fruits yields in ridge and bitter gourds, chillies, brinjal and tomatoes compared to farmers' practice **(Table 2)**. However, it was found that the magnitude of yield increase is more in tomato compared to farmers practice. The trials showed significant response of vegetables to micronutrient application like field crops. B: C ratio was higher in case of tomato (11.4) followed by green chilli (4.26), brinjal (4.19), bitter gourd (2.71) and ridge gourd (1.87). Among crops, tomato responded well to micronutrient application resulting an additional net

Table 2 – Response of vegetables to balanced nutrition in Sujala watersheds, Dharwad and Haveri districts of Karnataka, India							
Crop	Fresh fruit yield (q ha^{-1})		Farm gate price (Rs q^{-1})	No of farmers	Additional cost (INR ha^{-1})	Additional net returns (INR ha^{-1})	BC ratio
	FP*	IP**					
Ridge gourd	54	63 (16%)	600	2	3050	5700	1.87: 1
Bitter gourd	30	39 (30%)	925	2	3050	8250	2.71:1
Green chillies	60	85 (41%)	550	4	3050	13000	4.26:1
Brinjal	60	80 (33%)	681	4	3050	12770	4.19:1
Tomato	112	171 (52%)	638	4	3050	34800	11.4:1

FP*: farmers' practice:IP**: NP+ SBZn : 150 kg urea, 75 kg DAP, gypsum 200 kg borax 5 kg and 50kg $ZnSO_4$ ha^{-1} (% increase is given in paranthesis)

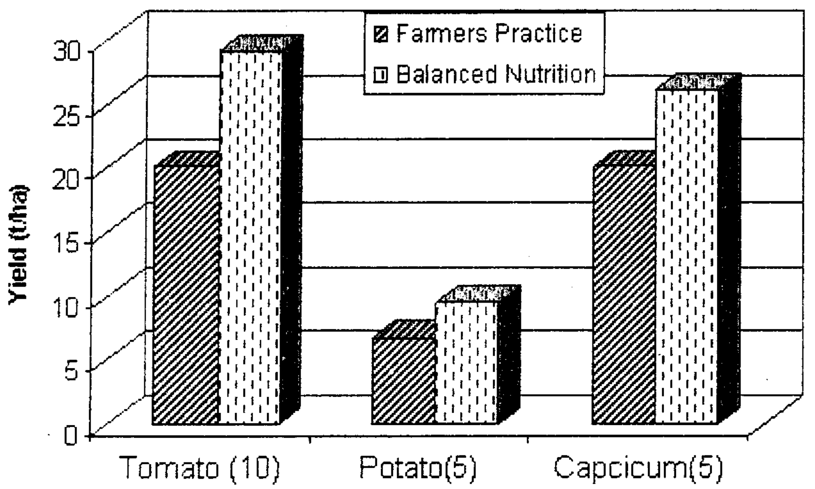

Figure 1 – Impact of balanced nutrition on yields of vegetables in Kolar and Chikkabalapur districts of Karnataka (Figures in Parenthesis indicates no of farmers fields)

returns of Rs. 34,800/- ha^{-1} followed by green chillies (Rs. 13000/- per hectare) and brinjal (Rs. 12770/- per hectare). Similar extent of responses were obtained in case of garlic with the application of boron and zinc on new alluvial soils of West Bengal (10).

Response of Vegetables to Balanced Nutrition in Chitradurga, Kolar, Tumkur and Chikballapur Districts of Karnataka

In Belaganahalli watershed, Kolar district and in Pulsanivaddu and T. Peddahalli watersheds of Chikaballapur, tomato yield increases were ranged from 16.0 to 20.4 t ha^{-1} 27.0 to 30.1 t ha^{-1} with balanced nutrition including micronutrients. Potato yields increased from 6.7 t ha^{-1} (farmers practice) to 9.5 t ha^{-1} with balanced nutrition. Similarly, capsicum yields increased from 20 t ha^{-1} to 26 t ha^{-1} (**Figure 1**). In Tumkur district, brinjal yields were improved substantially bringing additional income of Rs. 57,000/- per ha.

Impact of balanced nutrition on onion yields and economics in three watersheds of Chitradurga district is presented in **Table 3**. In Maradihalli watersheds the mean yields increased form 24.8t ha^{-1} to 34.5 t ha^{-1} (41%). Net returns improved from Rs. 41250 to 80000 with balanced nutrition showing advantage of Rs. 38750 ha^{-1} due to balanced nutrition. In

Table 3 – Impact of balanced nutrition on onion yields and economics in different watersheds in Chitradurga district of Karnataka									
Watershed	No. of farmers		Total yields (t ha^{-1})			Net returns (Rs ha^{-1})			Advantage with BN (Rs ha^{-1})
			FP	BN	% increase	FP	BN	% increase	
Maradihalli	10	Range	21-30	30-37.5	41	22500-67500	57500-95000	116	20000-50000
		Mean	24.8	34.5		41250	80000		38750
Toparamalige	10	Range	22.5-31.5	27.0-38.8	31	30000-75000	42500-	70	12500-63750
		Mean	26.7	34.7		50875	81125	101250	30250
Belagatta	4	Range	22.5-31.5	27.0-38.8	45	30000-75000	42500-101250	108	12500-68750
		Mean	27.3	35.6		54172	85609		36125

FP = Farmers practice; BN = Balanced nutrition (S, Zn, B along with NP)

Table 4 – Impact of foliar spray of micro and secondary nutrients on yields and economics in onion in Chitradurga district of Karnataka (No. of farmers fields = 15)

Treatment	Yield (t ha^{-1})	% increase	Net returns (Rs.)	% increase	Advantage with with foliar nutrition
Farmers practice (no Zn + B)	21.0 - 31.5 25.7	- -	22500-75000 46167	-	-
Foliar spray	25.0 - 33.8 29.4	15	38750-82500 60750	38	7500-25000 14583

Toparamalige watershed, the mean onion yields improved from 26.7 to 34.7 t ha^{-1} (31%). The advantage in net returns due to balanced nutrition was Rs. 30250 ha^{-1}. In Belagatta watershed also similar yield benefits were recorded. In several field experiments, significant yield responses were reported in onion to application of sulphur and zinc (6). Such responses in case of all the vegetables studied was due to severe deficiencies of these micro and secondary nutrients in soils of these watersheds.

Similarly, impact of foliar spray of zinc and boron were observed on onion yields (**Table 4**). The mean yield increase was from 25.7 t ha^{-1} to 29.4 t ha^{-1} (15%). In terms of net returns, the increase was from Rs. 46167 to 60750 (increase 38%). The advantage with foliar spray of Zn and B was Rs. 14583 ha^{-1}. Based on field experiments, Beri et al. (1) reported the potato yield increase of 22 per cent with combined foliar application of Zn, B , S and Mg in old Brahmaputra flood plain soils of Bangladesh. Similar responses were obtained in case of tomato with foliar application of Zn (2).

CONCLUSIONS

RESULTS SUGGEST THAT BALANCED nutrition including secondary nutrients like sulphur and micronutrients (Zinc and Boron) improved the yields as well of economics of various vegetable crops in participatory watersheds. Foliar application of micronutrients also enhanced vegetable yields, significantly. Therefore, application of sulphur, zinc and boron along with N, P and K is essential depending up on soil test status.

FUTURE LINE OF WORK

1. Vegetable crops require large amounts of nutrients and nutrient requirements of vegetable crops need to be studied.

2. Deficiencies of secondary and micronutrients should be monitored in vegetable growing regions of India.

3. Impact of balanced nutrition on quality of vegetables needs to be studied.

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