POLICY PAPER 57

Value Added Fertilizers and Site Specific Nutrient Management (SSNM)

NAAS

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI
DECEMBER 2012

Value Added Fertilizers and Site Specific Nutrient Management (SSNM)

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December 2012

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CITATION : NAAS 2012. Value Added Fertilizers and Site Specific Nutrient Management (SSNM). Policy Paper No. 57, National Academy of Agricultural Sciences, New Delhi: 16 p.

Published by Mr H.C. Pathak, Executive Secretary on behalf of
NATIONAL ACADEMY OF AGRICULTURAL SCIENCES
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Preface

By 2025, India will have to annually produce 300 million tonnes of foodgrains as against the production of about 257 million tonnes in 2011-12, needing to produce additional about 55 million tonnes of foodgrains per annum from the same area or even lesser area as the area under foodgrains has declined from 124 million hectares in 2007-08 to 121 million hectares in 2009-10 due to increasing demand for non-agricultural uses. This is a Herculean task and needs due attention and effort. While plant breeders will continue their efforts for developing crop varieties with higher yield potentials, much of the increase in production has to come from an increase in productivity. As of today, there is a wide gap between the potential yield of food crops and the yields attained at the farm level. There is thus enough scope to increase the crop yields at farm level by developing best management practices (BMPs). Adequate and balanced NPK fertilization and efficient use of applied nutrients is going to be the key component of BMPs.

India has substantially enhanced its NPK consumption from a mere 0.07 million tonnes in 1950-51 to about 28 million tonnes in 2011-2012 (a 400 fold increase). However, the efficiency of fertilizer use is quite low, less than 40% in case of nitrogen in rice. Also due to increased application of NPK fertilizers to cereals and taking heavy harvests year after year, the soils have been depleted of secondary and micro nutrients. This was further accentuated by the use of non-sulphur containing fertilizers (urea and DAP) and the neglect of application of organic manures. This has led to widespread multi-nutrient deficiencies adversely impacting not only crop yields but also causing human nutritional deficiencies due to the food chain.

In order to end this unsustainable and unhealthy practice, the adoption of site-specific nutrient management practices and development of crop and soil specific customized fertilizers is called for. Also there is an urgent need to develop more efficient nitrogen fertilizers - the nutrient applied in the largest amounts. To discuss various issues on this subject, the National Academy of Agricultural Sciences organised a Brainstorming Session on “Value Added Fertilizers and Site-Specific Nutrient Management”, which was attended by scientists from ICAR institutes and State Agricultural Universities, officers from the Ministry of Agriculture and representatives from the fertilizer industry. The highlights and recommendations of the Brainstorming Session are contained in this Policy Paper, which I hope will promote the development and use of value-added and customized fertilizers in the country for enhanced and sustained crop productivity. Grateful thanks are due to Professor Rajendra Prasad for having convened the Session and steering this Policy Paper.

(R.B. Singh)
President, NAAS

Value Added Fertilizers and Site Specific Nutrient Management (SSNM)

1. PREAMBLE

Fertilizer has been the key input in augmenting foodgrain production in India as well as in the world. Post-Green Revolution, the increase in foodgrain production and fertilizer consumption in India has been phenomenal. While the foodgrain production increased from 74.2 million tonnes in 1967-68 to 257.1 million tonnes in 2011-12, the fertilizer (N + P_2O_5 + K_2O) consumption increased from 1.1 million tonnes to 27.8 million tonnes during the same period. Although these figures look quite impressive, the fact is that while fertilizer consumption during 1967-68 to 2011-12 increased 25.2 times, the increase in food grain production was only 3.3 times. A recent study by National Centre for Agricultural Economics and Policy Research showed that during 1966-67 to 1991-92, the growth rate in fertilizer consumption (Kg N + P_2O_5 + K_2O/ha) was 9.2% / yr and the growth rate in crop output (index number of production of all crops) was 2.8% / yr, while during the period 1998-99 to 2006-07 the growth rate in fertilizer consumption declined to 2.6% / yr and the growth rate in crop output was only 1.1% / yr. This was mainly due to a very low nutrient use efficiency. According to a recent study by the Project Directorate for Farming Systems Research (PDFSR), Modipuram and the Indian Agricultural Statistics Research Institute (IASRI), New Delhi, the crop response to fertilizer was only 8.6 kg grain/ kg N + P_2O_5 + K_2O) in case of cereals. This is attributed to the imbalanced use of NPK along with inadequate application of micronutrients.

The other concern is very low use efficiency of nitrogen; in rice it is only 30-40% of applied fertilizer N. Partial factor productivity of fertilizer N (PPFn) in India has declined from 91.1 kg/ha in 1970-71 to 21.3 kg/ha in 2005-06 (Table 1*).

Among many options, blending or coating of N fertilizers with nitrification inhibitors to increase N use efficiency is to be seriously investigated for developing more efficient N-fertilizers. The cost : benefit ratio of such materials may also take into account the benefits to the environment and ecology of the region / country. Another type of value added fertilizers that needs to be developed are fertilizers containing all needed nutrients for a crop and region to meet the need as per Site Specific Nutrient Management (SSNM). Yet another matter of concern is poor quality of micronutrient fertilizers.

Keeping the urgency of the above issues and concerns, the National Academy of Agricultural Sciences organised a Brain Storming Session on 17th October 2011.

*Footnote: All tables are assembled in Annexure

Dr. Rajendra Prasad, INSA Hon. Scientist and Ex ICAR National Professor was the convener of this Brain Storming Session. The main facts and points emerging out of the discussion are summarised below.

Professor R.B. Singh, while inaugurating the Brainstorming Session pointed out that the fertilizer is the key input in not only augmenting the food production but also in overcoming the malnutrition with reference to micronutrients, such as, iron whose deficiency leads to anaemia, which is quite prevalent in pregnant women in Asian and African countries. Zinc deficiency syndrome next to iron deficiency is also reported globally. There was a mortality of about 450,000 children in 2004 due to Zn malnutrition. The most common disease due to Zn deficiency is diarrhoea in infants. These problems can easily be overcome with the use of secondary and micronutrient fortified/ customized fertilizers for different crops and regions.

2. SULPHUR DEFICIENCY IN INDIAN SOILS

It was brought out in the discussion that as per information available from the Indian Institute of Soil Science, Bhopal, about 41% of Indian soils are deficient in sulphur (S). The list of districts in different States, where more than 40% soil samples were found to be deficient in available S is given in Table 2. It is due to the large scale use of S-free fertilizers, such as urea and DAP, year after year heavy harvests without S application and virtually no supplement of organic manures.

Response to S fertilization has been reported in all crops (Table 3). Sulphur is considered important for oilseeds in general and for mustard/rapeseed in particular.

3. MICRONUTRIENT DEFICIENCIES IN INDIA

About 48.5 per cent of Indian soils are deficient in micronutrient zinc (Zn) (it is expected to aggravate to 65 per cent by 2025), 33 per cent are deficient in boron (B) and 12 per cent are deficient in iron (Fe). Zn deficiency is reported to be the highest (40-86 per cent samples found deficient in available Zn) in Haryana, Punjab, Uttar Pradesh, Bihar, Orissa, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu, followed by Assam and West Bengal (30-40 per cent soil samples deficient in available Zn). Further, most boron (B) deficient soils (32-65 per cent Deficient Soil Sample) are in Bihar, West Bengal and Karnataka. State-wise deficiency of micronutrients is given in Table 4.

Of all the micronutrients, Zn is most widely deficient in Indian soils and crop response to Zn has been reported for almost all crops. Some data are given in Table 5. Cereals, specially rice responds well to Zn fertilization on almost all kinds of soils.

Since boron deficiency is severe in the eastern States, on-farm trials with boronated NPK fertilizer were conducted in that region and the results obtained showed a good response to B fertilization (Table 6).

In addition to the wide-spread deficiencies of Zn and B, a good response of wheat to foliar application of manganese (Mn) was reported on sandy soils of Punjab (Dhaliwal *et al.*, 2011). Similarly, a good response of barley to copper fertilization was reported from the Doon Valley (Kumar *et al.*, 2010).

4. VALUE-ADDED/FORTIFIED FERTILIZERS

The deficiency of secondary and micronutrients can thus be overcome by fortification of the presently manufactured N/P/NP/NPK fertilisers to develop value-added/fortified fertilizers. Given below is the list of such fertilizers that have been approved by the Govt. of India (The Fertilizer Control Order of 1985 amended up to January 2011). Formulations are given as % of N, P as P_2O_5, K as K_2O, Zn, B).

1. Boronated single superphosphate (16P0.15-0.20B)
2. Zincated urea (43N2Zn)
3. Zincated phosphate (suspension) (12.9P19.4Zn)
4. NPK fertilizer fortified with B (10N26P26K0.3B)
5. NPK fertilizer fortified with B (12N32P16K0.3B)
6. DAP fortified with B (18N46P0.3B)
7. NPK fertilizer fortified with Zn (10N26P26K0.5Zn)
8. NPK fertilizer fortified with Zn (12N32P16K0.5Zn)
9. Calcium nitrate with B (14.6N0.25B)

5. MULTI-NUTRIENT DEFICIENCIES AND SSNM

The data presented in Tables 2 through 6 suggest that most soils in India have deficiencies of S and one or more micronutrients in addition to NPK deficiencies i.e. they have multi-nutrient deficiencies. This has led to the concept of Site-Specific Nutrient Management (SSNM). Some data on comparative response to fertilizer application on the basis of SSNM, State recommendations (SR) and farmers general practice (FP) are presented in Table 7 to highlight the significance of SSNM; more data are available with the PDFSR, Modipuram and the Indian Institute of Soil Science (IISS), Bhopal. The data in Table 7 clearly show that the FP even though contained higher levels of N or P than SSNM gave lower yields thus advocating the superiority of SSNM.

6. CUSTOMIZED FERTILIZERS

There is an urgent need for developing customized fertilizers for different regions and crops. Some progress in this direction has already been made and a list of approved formulations of customized fertilizers is given in Table 8. However, much more needs to be done in this direction and it has to be kept in mind that customized fertilizers can be developed only for large areas as manufacturers can not make too many grades.

7. NUTRIENT BASED SUBSIDY

Govt. of India's nutrient based subsidy (NBS) is helping the development, manufacturing and marketing of balanced/fortified/customized fertilizers, however, some grades being produced are too high in P and K. Although, it is argued that these fertilizers are only for basal application, there is no guarantee that these fertilizers will not be used for top dressing. In that case, the farmer will be paying for the nutrients which are not generally recommended for top dressing. At this juncture, it was brought out in the discussion that unless urea is also brought under NBS, real impact of fortified/customized fertilizers cannot be felt. It was pointed out by Dr. Kaore that soil scientists and agronomists should exercise some restraint while making recommendations for customized fertilizers, because it is not feasible for fertilizer manufacturers to enlarge the number of products.

8. MORE EFFICIENT NITROGEN FERTILIZERS

Use efficiency of fertilizer nitrogen, which constitutes more than 60% of total plant nutrients consumed in India is abysmally low; 30-40% in rice and 40-60% in other crops. Nitrogen use efficiency can be increased by treating urea with nitrification inhibitors or coating with some hydrophobic substances to retard the release of urea in soil solution or its microbial oxidation to nitrates, which leach down or are lost to the atmosphere as N_2 or NOx gases. The global warming potential (GWP) of NO_2 is about 310 times that of CO_2. Nitrates leached down increase the nitrate content in groundwaters above the safety limit of 45 mgL^{-1}, which can lead to health disorders in humans, especially in infants causing methaemoglobinemia (Blue baby syndrome). A recent report from Punjab indicated the increase in nitrate content in water of some shallow wells. Thus, low nitrogen use efficiency not only leads to financial loss to the farmers and government, it also creates environmental problems. Development of efficient low-cost, slow-release fertilizers is therefore an immediate necessity of the country and world as a whole.

Professor H.S. Gupta, Director, Indian Agricultural Research Institute (IARI), New Delhi informed that IARI has played a lead role in this direction by developing neem oil coated urea. He informed the participants that some new nitrification inhibitors are being developed at IARI.

Dr. Virendra Kumar observed that IFFCO has always been a front runner in this direction and long back had produced and organised field trials with Urea Super Granules (USG). The results obtained from several regions were very encouraging. He urged that Government of India may identify the area and crops for its use. He also informed that USG is being used in several foreign countries including Bangladesh in rice.

9. WATER SOLUBLE FERTILIZERS

The area under micro-irrigation is on the increase. This has focused attention on water soluble fertilizers (WSFs). WSFs approved by the Government and marketed in India are given below (FAI, 2011).

1. Potassium nitrate (13:0:45)
2. Mono potassium phosphate (0:52:34)
3. Potassium sulphate (0-0-50)
4. NPK fertilizer (13:40:13); (18:18:18 +2MgO+TE); (6:12:36); (19:19:19)
5. Urea phosphate (17:44:0)
6. Mono ammonium phosphate (12:61:0)

In view of SSNM, it is important that WSFs having requisite NPK and secondary and micronutrients are developed. Because of the precipitation of phosphates of cationic micronutrients (Fe, Zn, Mn) in solutions containing orthophosphate, use of ammonium polyphosphate could be very useful in developing production of water soluble multi-nutrient fertilizers and this deserves immediate attention.

10. LIQUID FERTILIZERS

Manufacturing and use of liquid fertilizers can save considerable energy spent on solidifying the fertilizer in the factory. National Fertilisers Ltd, Nangal had some time back developed a liquid fertilizer ‘Ankur’ which was found to be as good as urea and calcium ammonium nitrate for wheat (Singh and Prasad, 1985). Liquid fertilizers are being used on a large scale in USA, where they have developed necessary appropriate storage, transport and application equipment. These are pre-requisites for marketing and use of liquid fertilizers. The major advantage in promoting liquid fertilizers is creation of a new auxiliary industry that may create jobs for thousands of people. Also, India may be able to market this technology at least in SAARC countries. Given the better transport infrastructure, the demand for liquid fertilisers should be on the rise.

It was pointed out by Shri I.K. Suri that urea plants are recycling a part of their effluents at a fairly high cost and even then have to strip off some urea before allowing it to flow in the plant water stream. A 1000 tonnes per day (TPD) plant discharges about 20-25 m^3/hr effluent containing 0.8 to 1.5 % urea (by weight) and 4-5% ammonia (by weight). With some more effort, this effluent can be developed into a liquid fertilizer. Urea plant effluent can also be used for developing a slow release nitrogen fertilizer by co-precipitating it with neem oil. This technology was developed at the Indian Agricultural Research Institute, New Delhi and the product was named as Pusa Neem Gold Urea. It is a coral shaped golden yellow adduct (35% N as urea and 12% neem oil) and in a field trial at IARI gave 36% higher grain yield of rice at 120 Kg N/ha (Prasad *et al.*,1998).

11. IMPROVING THE QUALITY OF MICRONUTRIENT FERTILIZERS

Zinc sulphate hepta hydrate (ZSHH) is the most popular Zn-fertilizer in India. However it dehydrates at temperatures above 35^{o}C, which are generally prevalent during summer in India. Loss of water by dehydration of ZSHH can be as high as 25% at 40^{o}C and above. This results in the formation of lumps, which have to be broken by pounding before application in the field. A simple technique of conditioning ZSHH using ZnO and neem oil has been developed at the Indian Agricultural Research Institute, New Delhi (Suri *et al.*, 2011), which not only prevents lump formation, but also increases its Zn content by about 1%. If price incentive for this increase in Zn content is provided, the ZSHH manufacturers can overcome the cost of conditioning.

Recommendations

Policy

1. An All-India centre for R&D on fertilizer materials may be established without any further delay. This centre should have the following mandate:
   (i) Develop new VAF products and technologies.
   (ii) Serve as a referral laboratory for VAF
   (iii) Recommend safe application practices of VAFs based combination products.
   (iv) Develop appropriate fertilizer application equipments.
   (v) Serve as a repository of reference samples of VAF products developed / used in the country.
   (vi) Develop database on VAFs including global information on research and development and
   (vii) Provide advisory and consultancy service to the stakeholders.
2. The process of approving, pricing and incorporation in Fertilizer Control Order by Govt. of India for Value Added Fertilizers needs to be accelerated. It is recommended that a special committee consisting of senior representatives of the Ministry of Agriculture & Co-operation, Ministry of Fertilizers & Chemicals, ICAR and the fertilizer industry be constituted to examine various issues pertaining to

value added fertilisers and make appropriate recommendations to the Govt of India. The Committee should function on the lines of Central Varieties Release Committees for different crops in India for deciding upon the new VAFs to be manufactured in India. The committee should meet at least twice (before *kharif* and *rabi* seasons) a year.

3. Agronomic evaluation of newly developed VAFs should be restricted to the crops and regions for which these are developed. An All-India evaluation is not required.
4. Production of urea super granules (USG) may be approved for a few manufacturers for experimental purposes.
5. Strict quality assurance of VAFs including water soluble and liquid fertilizers should be in place.

Research

The following are the priorities in research agenda of ICAR institutes / SAUs and R&D units of the fertilizer industry.

6. Development of crop-region specific customized fertilizers. In developing these fertilizers, special precautions are needed when boron, copper, manganese and molybdenum are incorporated in N/NP/NPK fertilizers, because there is a narrow margin between deficiency and toxicity limits of these nutrients.
7. Development of low cost indigenous nitrification inhibitors and nano-VAFs.
8. Coating of N/NP/NPK fertilizers with bio-degradable polymers, nano clay, gypsum and other low cost indigenous materials.
9. Development of liquid fertilizers utilising the effluents from the urea plants.
10. Development of bio-impregnated phosphate fertilizers.
11. Development of suitable equipment for application of USG and liquid fertilizers.
12. Development of techniques of improving the storage quality of micronutrient fertilizers, such as zinc sulphate.
13. All the new products, techniques and equipments developed should be tested in a large number of on-farm trials in addition to their evaluation at research centres. The results obtained should be presented by the researchers / on-farm trial supervisors to the committee constituted as per recommendation (ii) under Policy

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Annexure

Table 1. Partial factor productivity (PPFn) in cereal production in India.

Year	Cereal Production (Mt)	Nitrogen consumption		PPFn (kg grain per kg N)
		(Mt)	(kg/ha)	
1970-71	96.6	1.06	10.4	91.1
1975-76	108.0	1.55	14.9	69.7
1980-81	119.0	2.65	25.4	44.9
1985-86	137.1	4.07	39.3	33.7
1990-91	162.1	5.76	55.8	28.1
1995-96	168.1	7.07	71.6	23.8
2000-01	185.7	7.86	78.0	23.6
2005-06	195.2	9.16	92.3	21.3

1. Nitrogen consumption by cereals taken as 72% of total N consumption in India.
2. PPFn determined by the expression: Cereal production (kg/ha)/ Nitrogen consumption/ha

Source: Fertilizer Statistics 2010, FAI, New Delhi.

Table 2. Districts / regions in different states having more than 40% soil samples deficient in available S

State	Districts/regions
Andhra Pradesh	Adilabad, Cuddapah, Nalgonda,Chittoor, Anantpur,Karimnagar,Medak
Bihar	Laxmipur, Navada, Samastipur
Chhatisgarh	Rajnandgaon
Gujarat	Sabarkhanda, Banaskantha,Panchmahal, Mehsana, Bharuch
Haryana	Ambala, Faridabad, Hisar
Jharkhand	Ranchi, W.Singhbhum, E.Singhbhum, Dumka, Lohardaga
Karnataka	Dakshin Kannada, Uttar Kannada, Malnad area
Kerala	Idduki, Palghat
Madhya Pradesh	Dewas, Ujjain, Seoni, Mandsaur, Dhar, Khandwa, Morena, Bhind, Gwalior, Sidhi, Sehore, Indore, Chhindwara
Maharashtra	Ahmednagar, Ratnagiri
Odisha	Kalahandi, Bragarh, Sambalpur
Punjab	Ropar, Ludhiana, Amritsar, Hoshiarpur
Rajasthan	Chittorgarh, Alwar, Dholpur, Banswara

Contd...

Contd...

State	Districts/regions
Tamil Nadu	Madhurai, S.Arkot, Vellore, Salem, Cuddalore
Uttar Pradesh	Lucknow, Hardoi, Kanpur, Unnao, Varanasi, Gazipur, Mirzapur, Banda, Pratapgarh, Faizabad, Raibareilly, Bhadohi, Fatehpur, Sonebhadra, Aligarh, Jhansi, Gorakhpur

Source: Hegde, D.M. and Sudhakara Babu, S.N. (2007) *Indian J. Fertilisers. 3(1): 65-79.*

Table 3. Average crop response to S fertilization in some on-farm trials

Crop	Trials (Nos)	Optimum S dose (kg/ha)	Response (kg grain/kg S)
Rice	53	30	29.2
Maize	12	30	28.5
Mustard	9	15	28.4
Pearlmillet	9	45	19.6
Wheat	3	45	19.2
Sorghum	3	30	16.0
Groundnut	11	30	12.0 (Pods)
Sunflower	5	45	11.1
Soybean	5	45	10.0
Blackgram	3	45	8.5
Greengram	4	30	4.2

Source: Tewatia, R.K., Choudhary, R.S. and Kalwe, S.P. (2006). TSI-FAI-IFA Sulphur Project-Salient Findings. Proc. TSI-FAI-IFA Symposium-cum-Workshop Sulphur in Balanced Fertilization, Oct.4-5, New Delhi. pp. 15-25.

Table 4. Extent of micronutrient deficiencies in major states of India

State	Number of Samples analysed	Deficient soil samples (%)				Number of Samples analysed	DSS (%)
		Zn	Cu	Fe	Mn		
Andhra Pradesh	8158	49.4	<1	3	1	-	-
Assam	12165	34.0	<1	2	20	-	-
Bihar	19214	54.0	3	6	2	5270	38
Delhi	201	20.0	-	-	-	-	-
Gujarat	30152	23.8	4	8	4	2480	2
Haryana	21848	60.5	2	20	4	180	0

Contd...

Contd...

State	Number of Samples analysed	Deficient soil samples (%)				Number of Samples analysed	DSS (%)
		Zn	Cu	Fe	Mn		
Himachal Pradesh	155	42.0	0	27	5	-	-
Jammu & Kashmir	93	12.0	-	-	-	-	-
Karnataka	27860	72.8	5	35	17	21562	32
Kerala	650	34.0	31	<1	0	-	-
Madhya Pradesh	32867	43.9	<1	7	1	2813	22
Maharashtra	515	86.0	0	24	0	-	-
Orissa	16040	54.0	-	0	0	-	-
Punjab	16483	48.1	1	14	2	263	13
Rajasthan	183	21.0	-	-	-	-	-
Tamil Nadu	28087	58.4	6	17	6	1031	21
Uttar Pradesh	26126	45.7	1	6	3	49	24
West Bengal	6547	36.0	0	0	3	3177	68
All India	251660	48.5	3	12	5	36825	33

Source: Gupta, S.P., Singh, M.V. and Dixit, M.L. (2007) *Indian J. Fertilisers* 3(5): 57-60.

Table 5. Yield increase in some crops due to Zn fertilizaion in on-farm trials

Crop	Number of Trials	Yield increase range (t/ha)	Average increase (t/ha)
Cereals			
Rice	910	0-4.8	0.76
Wheat	1172	0-4.7	0.38
Maize	285	0-3.4	0.67
Pearl millet	240	0-0.8	0.21
Sorghum	34	0-1.3	0.48
Finger millet	34	0-1.2	0.35
Pulses			
Chickpea	14	0.04-0.4	0.20
Black gram	14	0-1.1	0.23
Green gram	7	0.06-0.45	0.21
Lentil	8	0.06-0.27	0.17
Pigeonpea	4	0.08-0.27	0.16

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Crop	Number of Trials	Yield increase range (t/ha)	Average increase (t/ha)
Oilseeds			
Mustard	2	0.31-0.45	0.38
Soybean	5	0.12-0.69	0.38
Sesamum	2	0.09-0.12	0.11
Cash crops			
Potato	5	0-5.9	2.86
Onion	3	2.16-3.76	3.01
Cotton	26	0-0.78	0.24 (seed cotton)
Sugarcane	2	9.8-24.6	17.2 (millable canes)

Source: Rattan, R.K., Datta, S.P. and Katyal, J.C. (2008). *Indian J. Fertilisers* 4(12): 99-118.

Table 6. Effect of boronated NPK (10-26-26-0.3B) on the yield of some crops in on-Farm trials in eastern India

State (soil)	Crop	Trials (Nos)	Grain yield (t/ha) with		% increase with BNPK over NPK
			NPK	BNPK	
W. Bengal	Mustard	5	1.20	1.45	20.8
(Alluvial)	Wheat	2	2.35	2.63	11.9
W. Bengal	Mustard	5	1.11	1.31	19.1
(Terai)	Wheat	7	2.64	2.89	9.4
	Potato	5	30.0	33.4	13.2
Jharkhand (Red)	Cauliflower	13	11.5	12.4	7.7
Odisha	Potato	2	35.0	39.5	12.8
(sandy)	Tomato	1	42.2	44.3	4.8
	Chili(dry)	1	1.74	1.84	5.4

Source: Sarkar, D., Mandal, B., Sarkar, A.K., Singh, S., Jena, D., Patra, D.P. and Phillips M., (2006) *Indian J. Fertilisers* 1(12): 57-59.

Table 7. Comparative grain yield of rice with SSNM, SR and FP at selected research centres under PDFSR, Modipuram

Centre (state)	Fertilizer recommendation (kg/ha)	Yield (t/ha)	Increase (t/ha)	Over FP (%)
Sabour	SSNM (150N30P100K40S)	8.23	3.27	66
(Bihar)	SR (100N40P40K)	6.03	1.07	22

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Centre (state)	Fertilizer recommendation (kg/ha)	Yield (t/ha)	Increase (t/ha)	Over FP (%)
	FP (60N30P)	4.96	-	-
Palampur	SSNM (100N25P80K40S20Zn5B)	5.28	1.14	28
(H.P.)	SR (100N30P30K)	4.70	0.56	14
	FP (80N20P)	4.14	-	-
Ludhiana (Punjab)	SSNM (150N60P150K40S25Zn5B20Mn)	10.43	1.30	14
	SR (120N30P30K25Zn)	9.81	0.67	7
	FP (180N60P10Zn)	9.13	-	-
Kanpur	SSNM (150N30P120K50S40Zn)	9.23	2.34	34
(U.P.)	SR (150N75P60K25S)	8.28	1.39	20
	FP (80N30P)	6.89	-	-
Modipuram (U.P.)	SSNM (150N30P80K20S25Zn5B20Mn)	10.18	3.16	45
	SR (150N75P75K25Zn)	7.73	0.7	10
	FP (180N60P25Zn)	7.03	-	-
Varanasi (U.P.)	SSNM (150N30P80K40S40Zn5B20Mn20Cu)	7.03	1.0	17
	SR (150N75P60K25Zn)	6.53	0.5	8
	FP (180N60P25Zn)	6.02	-	-

Note: SSNM-Sight Specific Nutrient Management; SR-State Recommendation; FP-Farmers' Practice;

P refers to P2O5 and K to K2O, S as elemental S, Zn as zinc sulphate, B as Borax, Cu as copper sulphate and Mn as manganese sulphate.

Source: Singh, V.K. *et al.* (2008) *Better Crops India* **2**:16-19.

Table 8. Formulations of Customized Fertilizers as approved by Govt. of India as on 01-11-2011 (Fai 2011).

S.No.	Formulation	Crop	Region	Fert. Co.
1.	7N20P18K6S0.5Zn*	Sugarcane	Western U.P.	TCL**
2.	10N18P25K3S0.5Zn	Wheat	Western U.P.	TCL
3.	8N15P15K0.5Zn0.15B	Rice	Western U.P.	TCL
4.	8N16P24K6S0.5Zn0.15B	Potato	Western U.P.	TCL
5.	15N32P8K0.5Zn	Rice	Andhra Pradesh	NFCL
6.	18N33P7K0.5Zn	Rice	Andhra Pradesh	NFCL

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S.No.	Formulation	Crop	Region	Fert. Co.
7.	18N27P14K0.5Zn	Rice	Andhra Pradesh	NFCL
8.	18N24P11K0.5Zn	Rice	Andhra Pradesh	NFCL
9.	23N12K	Rice	Andhra Pradesh	NFCL
10.	27N10K	Rice	Andhra Pradesh	NFCL
11.	11N24P6K3S0.5Zn	Rice (basal)	Adilabad, Nizamabad Karimnagar, Warangal Medak, Ranga Reddy Nalgonda (All in A.P.)	NFCL
12.	14N27P10K4S0.5Zn	Maize	do	NFCL
13.	22N12K	Rice	do	NFCL
14.	18N14K	Maize	do	NFCL
15.	10N20P10K5S2Mg 0.5Zn0.3B0.2Fe	Grape (basal) & Sugrarcane	Nasik, Pune, Ahmed nagar, Aurangabad	Deepak F.
16.	20N10P10K5S2Mg 0.5Zn0.3B0.2Fe	Grape, Rice Pomegranate Sugarcane, Tomato etc.	-do- & Dhule, Jalgaon	Deepak F.
17.	15N15P15K5S2Mg 0.5Zn0.3B0.2Fe	Grape, cotton Onion, Banana, Tomato etc.	do	Deepak F.
18.	10N20P20K3S2Mg 0.5Zn0.3B0.2Fe	Sugarcane, Citrus	do	Deepak F.
19.	15N15P15K0.5Zn0.2B	Groundnut	Andhra Pradesh	Corom.Int.
20.	20N15K0.5Zn0.2B	Maize	Andhra Pradesh	Corom Int.
21.	16N22P14K4S1Zn	Rice (basal)	E &W Godavari Krishna, Western Delta of Guntur (All in A.P.)	Corom Int.
22.	14N20P14K4S0.5Zn	Maize	Karimnagar, Warangal Nizamabad	Corom Int.
23.	17N17P17K4S0.5Zn0.2B	Groundnut (basa)	Anantapur, Chittoor Kadappa, Kurnool Mahabubnagar	Corom Int.
24.	12N26P18K5S0.5Zn	Rice and Wheat	Uttar Pradesh	Indo-Gulf
25.	8N18P26K6S1Zn0.1 B	Potato	Uttar Pradesh	Indo-Gulf

*%N,P_2O_5,K_2O,S, Mg, Zn, B and Fe
** TCL-Tata Chemicals Ltd.; NFCL-Nagarjun Fertilizers & Chemicals Ltd.; Deepak F.-Deepak Fertilizers; Corom Int-Coromandel International Ltd.; Indo-Gulf-Ingo-Gulf.

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