CONVENER : **Dr. Rajendra Prasad**, Former ICAR National Professor, IARI & INSA Hon. Scientst, New Delhi

EDITORS : **Dr. Rajendra Prasad**
: **Dr. P.S. Pathak**

CITATION : NAAS 2009. "Crop Response and Nutrient Ratio". Policy Paper No.42, National Academy of Agricultural Sciences, New Delhi pp __.

Published by Secretary on behalf of
NATIONAL ACADEMY OF AGRICULTURAL SCIENCES
NASC Complex, Dev Prakash Shastry Marg, Pusa Campus, New Delhi 110012
Tel: (011) 25846051-52; Fax: (011) 25846054
Email: naas@vsnl.com; Web site: http://www.naasindia.org

CROP RESPONSE AND NUTRIENT RATIO

PREAMBLE

By 2020, India will need 294 million tonnes of food grains as against a provisional production of 230 million tonnes in 2007-2008. Thus, an additional food grain production of 64 million tonnes has to be achieved from the same or even lesser land area, because some area will have to be diverted to civil works such as urban housing, roads, railways, industrial units etc. This additional production has, therefore, to come through efficient, judicious and balanced use of chemical fertilizer.

A NPK ratio of 4:2:1 ($N:P_2O_5:K_2O$) is generally considered ideal and accepted for macro-level monitoring of consumption of plant nutrients for the country as a whole. However, it is difficult to trace the genesis of this NPK ratio.

After attaining independence in 1947, India's major concern was adequate food grains and fertilizer was considered an important tool to boost food grain production in the country. On the recommendation of Dr. A.B. Stewart (1947) of the Macaulay Institute of Soil Research, Scotland, UK, who was invited to India, a large number of fertilizer trials were initiated on the farmers fields in 1951 in 7 states. Dr. Frank W. Parker, the then Director, USAID in New Delhi and Agricultural Adviser to the Ministry of Food and Agriculture, Govt. of India also played a key role in the encouragement of fertilizer use in agriculture. Experiments on fertilizers rapidly extended all over India under TCM scheme and in 1956, a Coordinated Agronomic Experiments Scheme was launched for conducting a large number of on-farm trials (about 15000 per year) and replicated experiments at research centres known as Model Agronomic Experiments. The scheme was later named as All India Coordinated Agronomic Experiments Scheme in 1964 and re-named as All India Coordinated Agronomic Research Project (AICARP) in 1969. This was Pre-Green Revolution era and only small amounts of fertilizer were used by farmers. Thus the doses were 22.4 to 44.8 kg $N/P_2O_5/K_2O$ per hectare. The data obtained from these on-farm trials showed that increase in yield and response to N was much more than that to P or K, and that the response to combined application of NPK was not positive or even additive. A close examination of these data also showed that in irrigated wheat the All India average increase in yield due to N, P and K fertilization was 3.7, 2.3 and 1.4 q/ha respectively, while in rice it was 3.0, 2.2 and 1.4 q/ha, respectively. This made fertilizer N very popular with the farmers. Probably some of these data played a key role in deciding upon the NPK* ratio of 4:2:1. Two things were, however, overlooked. Firstly, the yield levels were between 1 to 2 t/ha and the native soil P and K could meet the crop requirements. Farmers also used to apply farmyard manure on their farms. Secondly, response to P and K was much more on red and lateritic soils than on other soils, suggesting the need for a different NPK ratio for different soils. Post-Green Revolution trials under the same scheme brought out that in rice response to P was as good as to N and in case of wheat, it was even better than that to N. Response to K was much less than that to N or P. The introduction of high yielding varieties of wheat in 1967-68 made P fertilization quite popular in Punjab, Haryana and Western U.P. Further, response to N was higher in presence of P and K. This all brought balanced NPK nutrition to the forefront and farmers were quite convinced of this. The data obtained from the All India long-term Fertilizer Experiments, however, showed that barring Ludhiana for wheat neither the recommended fertilizer dozes nor yield or profit maximizing doses had NPK ($N:P_2O_5:K_2O$)* in 4:2:1 ratio. At Ludhiana in wheat both the yield and profit maximizing rates of NPK application were in 4:2:1 ratio. For rice at Bhubaneshwar having a laterite soil, the NPK ratio for yield or profit maximization ratio was 1.6:1:1 or 4:2.5:2.5. Similarly, for wheat at Ranchi having red soil the profit maximization ratio was 2:1.5:1 or 4:3:2. These data clearly showed the need for higher P and K application in red and lateritic soils.

The NPK needs of a farm are determined by crop and its variety, soil's capacity to supply these and the use efficiency of nutrients applied externally as fertilizer. These aspects are briefly discussed.

Nutrient needs of Crops

For producing a tonne of cereal grains about 20 – 27 kg N, 8 – 19 kg P_2O_5 and 24 – 48 kg K_2O are required, and the values are the highest for pearl millet producing the lowest grain yield per hectare. Grain legumes remove much more N (two to four times of that in cereals) but most of it is fixed by the *Rhizobium* on their roots and very little N as fertilizer has to be applied, say, 20 – 25 kg N/ha as a starter. However, P and K removal is higher in pulses than in cereals. Rapeseed also removes quite a bit of N and very high amounts of K. But in none of these, crops NPK removal is in 4:2:1 ratio. What is worth taking note is that 60 – 89% of K taken

* Throughout this Policy Paper read NPK ratio as $N:P_2O_5:K_2O$ ratio

up by a crop remains in straw and recycling it back to soil can meet bulk of K requirements of crops. In crops like pigeonpea about 60% of NPK remains in stover or residue. The average NPK uptake ratio for leguminous oilseeds works out to 4:1:4, while for repeseed / mustard it is 3.2:1.6:4 and for sunflower it is 2:0.6:4, indicating very high K removal by sunflower. Thus, oilseeds need as much K as N fertilization. Not only crops but varieties within a crop also differ in the ratio, in which NPK are needed to be applied. The climate can also influence the ratio, in which NPK are needed by crop plants.

Soil as a factor on NPK uptake and its ratio in crops

Soil due to native availability of NPK and other physical, chemical and biological properties also affects the supply and NPK uptake by crops.

Soil tests for N most commonly used in India include organic C or alkaline permanganate oxidizable N, while for available P, Olsen's 0.5 M sodium bi-carbonate extractable P is most widely used. 1 M ammonium acetate extractable or exchangeable K is the method for available K. Soils are generally classified as low, medium and high in available nutrients. What is worth taking note, is that soil test values are relative and not absolute values and the amounts of NPK to be applied depends on how well a soil chemist can relate it to likely response of a crop to be obtained on a soil, and this is where real refinement comes into picture. A procedure for such refinement was developed by Dr. Ramamoorthy at the Indian Agricultural Research Institute and is known as 'Targetted Yield Concept' and has been widely used in Soil Test Crop Response (STCR) studies. The fertilizer dose determined on the basis of targeted yield concept gave higher yields than those obtained with RDF (recommended dose of fertilizer). At Hisar having sierozems (Aridisols) K application recommended on the basis of STCR for Raya was zero, while in Palampur having Hapludalfs (sub-montane soil) it was only 5 kg/ha as compared to 40 kg/ha in the state RDF for *toria*. However, in Coimbatore having Vertic Ustochrepts (medium black) both N and K applications on STCR basis were much higher than state RDF for groundnut. At none of these research centres the recommended dose on STCR basis had a NPK ratio of 4:2:1.

Application of targeted yield concept can also take into account the application of nutrients applied through FYM or made available through biofertilizers resulting in reduced NPK application ratio.

Nutrient use efficiency (NUE)

NUE of nitrogen varies from 26 to 67% depending upon the crop and cropping system. The values for apparent recovery (AR) of N are generally higher than true recovery determined by using ^{15}N. A general AR value of 40 – 50% may be considered appropriate for N. For P the AR values vary from 21 to 37%, while that for K these vary from 41 to 56%.

Calculating fertilizer application rate

The amount of N or P_2O_5 or K_2O to be applied to a crop can be calculated from the expression:

Nutrient to be applied = [{yield(t/ha) x nutrient uptake (kg/t)} – {nutrient available in soil (kg/ha)}] x 100 / NUE

For example, for a crop of rice yielding 6 t/ha of grain and removing 20 kg N/t on a soil having 60 kg available N/ha and NUE 40%, the amount of N to be applied will be.

N to be applied (kg/ha) = [(6 x 20) – (60)] x 100/40 = 150 kg N/ha

To find out the optimum NPK ratio for different regions of the country and for different crops a **Brain Storming Session** on 'Crop Response and Nutrient Ratio' was organized by the National Academy of Agricultural Sciences on 28th and 29th May 2009 at New Delhi with Dr. Rajendra Prasad, Ex ICAR National Professor and INSA Honorary Scientist as the Convener. It was attended by 30 participants from ICAR and its institutions, State Agricultural Universities, Ministry of Agriculture and Fertilizer Association of India.

Technical Sessions

There were four technical sessions, three on 28th May and fourth on 29th May 2009. ***The first technical session*** was chaired by Prof. H.K. Jain, Vice President, National Academy of Agricultural Sciences and Chancellor, Central Agricultural University, Imphal. Professor Jain emphasized the importance of fertilizer in augmenting food production in the country, but pointed out that the focus has to be on the efficiency of its use rather than on the amounts applied. He mentioned that by the end of the 20th century, the ill effects of over-fertilization on the environment and human health were realized and the advanced countries are reducing fertilizer application, while increasing its efficiency. He re-emphasized the need for balanced fertilization and for increasing the efficiency of fertilizer use. He also observed that for best results district-wize fertilizer recommendation have to be worked out for different crops. In this session four presentations were made. Prof. Sanyal observed that while determining K fertilizer needs of crops, due attention has to be given to the mineralogical composition of soil. Dr. Subbarao pointed out the need for carefully analyzing the data on crop response to fertilizer, while Dr. Gill emphasized the need for keeping the cropping system rather than individual crop in view while making fertilizer recommendations. Dr. Venugopalan pointed out that fertilizer recommendations in cotton have considerably changed with the introduction and large scale cultivation of Bt cotton. He observed that as of today, specific recommendations for Bt cotton fertilization have not been made by the states/state agricultural universities, however, they are in the process of finalizing the recommendations for Bt cotton based systems.

The second technical session was chaired by Dr. A.K. Singh, DDG (NRM), ICAR. He informed the house, that soil fertility evaluation in 170 districts is being carried out under Department of Agriculture and Cooperation, Govt. of India funded project executed by IISS, Bhopal. He emphasized the need for finding out the nutrients added through irrigation and rain-water, for determining the effects of biomass burning and for finding the effects of climate on nutrient needs of crops. In this session three presentations were made. Dr. Srinivasa Rao emphasized the need for making the fertilizer recommendations based on exchangeable as well as non-exchangeable K. Dr. Hegde presented data on fertilizer recommendations for oilseeds, while Dr. Yadav presented data on fertilizer recommendations for sugarcane.

The third technical session was chaired by Dr. R.K. Gupta, Consultant (Soil Science), National Food Security Mission, Govt. of India, New Delhi and was mostly dedicated to examine the state fertilizer recommendations for different crops and for working out and suggesting broad recommendations. Dr. Biswas observed that a considerable amount of fertilizer was going to horticultural and vegetable crops.

The fourth technical session was chaired by Dr. R.L. Yadav, Director, Indian Institute of Sugarcane Research, Lucknow. It was decided to work out and suggest the desired NPK ratio for different agro-climatic zones and then if possible for different crops. Since cereals account for 69% of the total NPK consumed in India, the main emphasis was paid to them, and fertilizer recommendations worked out for different cropping systems in different agroclimatic zones by PDCSR, Modipuram served as the main source. For sugarcane, cotton, oilseeds and pulses the state fertilizer recommendations with comments from the Directors / Project Directors of the respective commodity Institute / Directorate served as the base material for discussion.

Pulses remove nearly half amount of K as compared to N (most N is through *Rhizobial* N fixation) and some K almost equal to starter N dose (20-25 kg/ha) is recommended in several states (Punjab, H.P., U.P., W. Bengal, Jharkhand, A.P., Karnataka, Kerala), while, other states do not recommend K. The general N : P_2O_5 : K_2O ratio of 1 : 2-3 : 1 appears alright for pulses. The same N : P_2O_5 : K_2O ratio also seems OK for leguminous oilseeds (groundnut, soybean). Nutrient uptake data in rapeseed-mustard show that it removes as much K as N, while in sunflower K removal is twice that of N. However, response of rapeseed / mustard to K was nil in Assam, W. Bengal, Gujarat, M.P. Maharashtra, Punjab and Rajasthan. Haryana, Rajasthan and Gujarat do not recommend K application to rapeseed / mustard, (N : P_2O_5 :K_2O ratio of 4 : 2: 0), while Punjab and U.P. recommended a N : P_2O_5 : K_2O ratio of 4 : 2: 2 for rainfed and 6 : 2-3 : 2 for irrigated crop. Since sunflower is a heavy remover of K, even more than cereals, most states recommended K application despite the fact that response of sunflower to K was reported only from T. Nadu. The N : P_2O_5 : K_2O recommended for sunflower in Punjab is 4 : 2 : 2, while in southern states (A.P. Karnataka, T. Nadu) N : P_2O_5 : K_2O ratio in fertilizer recommendations varies from 4 : 4 : 2 to 4 : 6 : 4 for rainfed crop and 5 : 6 : 2 to 5 : 6 : 5 for irrigated crop. But for eastern U.P. the N : P_2O_5 : K_2O recommendation for sugarcane is 4-5 : 2 : 2. K is not recommended for sugarcane in Haryana. Potassium is recommended in abundant amounts in potato and tobacco in all states.

Detailed N : P_2O_5 : K_2O ratios for different major crops in different agroclimatic zones are in **Annexure I**.

Broad Conclusions

The broad conclusion was that while the northern alluvial belt and shallow to medium black soils in the central plateau need some potassium suggesting a N : P_2O : K_2O ratio of 4:2:1, the northeastern region and coastal plains (both eastern and western) and southern states having red and lateritic soils need a little higher dose of K suggesting a N : P_2O_5 : K_2O ratio of around 4 : 2 : 2. However, in western dry regions of Rajasthan and Gujarat on deep black soils in control plateau (needs confirmation), there may be no need for K fertilization, suggesting a N : P_2O : K_2O ratio of 4:2:0. On such soils K may be applied if indicated by soil test.

It was brought out in the discussion that the efficiency of even balanced NPK fertilization remains low due to the wide-spread deficiencies of secondary (sulfur) and micronutrients (zinc, boron, manganese, iron). In addition to these deficiencies, soil amendments (gypsum on sodic soils and lime on acid soils) also need to be applied. Also, in many areas over-fertilization with nitrogen is not only mining soil of other plant nutrients but is also creating environmental and health problems such as enriching ground water with nitrates.

It was also brought out that the nominator in all the terms used for determining fertilizer use efficiency (agronomic efficiency or crop response ratio, recovery efficiency, physiological efficiency, partial factor productivity) is the crop yield, and for obtaining a good crop yield, a good agronomy package (optimum date of sowing/transplanting, optimum seed rate / plant population, optimum spacing, depth of planting, recommended crop variety / hybrid, good water and weed management and efficient plant protection etc.) is a must. Nevertheless much remains to be done in this direction.

RECOMMENDATIONS

Major recommendations emanating from the Brain Storming Session are given under two heads, namely, (A) agenda for research and (B) policy decisions.

A. Agenda for Research

1. The present method of determining available K in soils is I *M* neutral ammonium acetate exchangeable K. This method is not adequate to predict K supplying capacity of soil, since in most studies it has been brought out that non-exchangeable K (NEK) contributes 80-90 % of K removed by a crop. It is, therefore, desirable to have an estimate of 'NEK' in a soil. Furthermore, the 'Intermediate K' a fraction of the NEK is independent of the amount of K reserve (NEK) and depends rather on the clay mineral structure and its degree of expansion. There is a gap between the 'K-release threshold level' and 'K-fixation threshold level' in soil, the latter being generally higher. The appropriate K management practice has to evolve ways and means to maintain the exchangeable K level in soil at an optimum intermediate between

these two threshold levels. It is recommended that 'NEK' pool of soil be estimated as a regular soil testing protocol in addition to 1 *M* ammonium acetate exchangeable K.

2. Readily available technological inputs in augmenting nutrient use efficiency must be scaled up through supervised validation trials. Research in improving NUE must receive coordinated action.

3. Subsoil contributes considerably towards meeting nutrient needs of plants. However, soil testing is done only for surface soils. It is suggested that the nutrient resources in soil profile upto a depth of 1.5 m need to be monitored periodically and their share in meeting nutrient needs be determined. While doing so, root growth and proliferation must also be studied. Such studies are much more important for perennial horticultural crops and for these crops soil sampling protocols need to be standardized keeping in view the feeding zone.

4. Fertilizer needs for conservation tillage (zero-till with residues on the surface) need to be worked out.

5. For high yields, water and nutrient use efficiency, fertilizer application should be optimized in relation to optimum, sub-optimum and deficit irrigation situations.

6. Fertilizer needs for conservation irrigation (drip, sprinkler etc.) need to be worked and for different crops and soils.

7. A large number of farmers in the rice-wheat cropping system belt are burning rice straw in the field. Although some nutrients (N, S P, B) are partly lost on burning metallic plant nutrients (Ca, Mg, K, Fe, Zn, Cu, Mn) are left in soil. Estimates of these nutrients are urgently needed. Also needed are estimates of amount of C, N, S, P, B, etc lost due to burning.

8. With the combine harvesting of rice and wheat, a sizeable part of crop residue (stubbles) is left in a field. Estimates of residues returned and nutrient content in residue left in a field needs to be monitored.

9. Estimates of CO_2 and suspended particles generated by burning rice straw in the atmosphere, which is an environmental hazard, are urgently needed.

10. For high yields, water and nutrient use efficiency, fertilizer application should be optimized in relation to optimum, sub-optimum and deficit irrigation situations.

11. Considerable amounts of plant nutrients (specially N, K, S) may be added through irrigation water especially through groundwater. Estimates of such amounts of plant nutrients will help in determining the amounts to be added externally, which will help in increasing the efficiency of plant nutrients applied.

12. Consolidation of the knowledge generated, its synthesis and on-farm testing of research done on Integrated Nutrient Management (INM) aiming at reducing fertilizer application rates and increased use of green manures / dual purpose legumes, organic manures, crop residues and biofertilizers is urgently needed. The chief objective is to reduce direct application of chemical fertilizer and to recycle crop residues and organic manures.

13. Synergistic effects of micronutrients with macronutrients need to be carefully studied and Site Specific Nutrient Management (SSNM) package need to be developed for different crops / cropping systems for different agro-climatic zones.

B. Policy Decisions

1. A cell may be created at IASRI or NCAP to work out the optimum N : P_2O_5 : K_2O ratio in consultation with PDCSR, Modipuram, using the data on crop response to fertilizers from different sources (PDCSR, Crop Improvement Projects of ICAR, Soil Test Crop Response Correlation Project, Long term fertilizer experiments, state agricultural universities, state departments of agriculture, ICAR institutes). These ratios may be first worked out for different crops in 126 NARP zones. Weighted (area basis) N : P_2O_5 : K_2O ratios may then be worked out for different NARP zones, states and finally for the country as a whole. This needs to be done at a regular interval.

2. All SAUs should have a well equipped laboratory for analysis of all plant nutrients (primary, secondary and micro) in soil and plant samples. This is not to be restricted to the analysis of available nutrients in soils but should include total plant nutrient analysis in soil and plant samples.

3. All soil testing laboratories (STL's) especially district and regional laboratories in the country should be well equipped for the analysis of available macro and micronutrients including B and Mo, which are not included in DTPA extract, generally used for estimating available Fe, Mn, Cu and Zn. This will call for

additional funds, which need to be provided. Also qualified and trained staff should be appointed in STL's with some incentives. Further, training and updating of the staff of STL's in the SAU's should be a regular feature. Updating of equipments in the STL's should be done as and when required and separated funds may be earmarked for this.

4. Availability of fertilizers on time still remains a problem in several parts of the country. Methodology of fertilizer distribution needs to be improved.

5. Quality control of fertilizers including micronutrient fertilizers has to be assured.

6. Standardization of organic manures, their preparation methods and quality criteria needs to be done.

7. Development and production of value-added and site-specific customized fertilizers will help in increasing the nutrient use efficiency.

8. Recycling of plant nutrients is to be promoted. Use of organic manures such as FYM, compost, vermicompost etc. need encouragement.

9. Most of cow dung is still used as cakes for kitchen fuel purposes. However, the cow dung cake ash contains most of the metallic plant nutrients (Fe, Mn, Zn, Cu, K, Ca, Mg) and hence, its return to farm field will help in meeting part requirement of these nutrients. The awareness for this needs to be created among the farmers and the extension workers. Alternatives to cow dung cakes as a source of kitchen fuel need to be found.

10. Short duration energy plantations to produce biomass for fodder and firewood need to be encouraged and if possible subsidized.

11. The fertilizer subsidy must be audited with respect to NUE and long term effects on the environment.

12. Providing subsidy to promote cultivation of legumes for green manuring or / and grain to help in reducing nitrogen application and to overcome the shortage of pulses in the country.

13. Agricultural extension system needs to revamped.

14. Agricultural credit, input and technology delivery systems need to be synchronized.

15. Crop insurance needs to be provided specially for small and marginal farmers. This will encourage them to apply needed amounts of fertilizer and other inputs.

16. Availability of good quality of seed of the recommended variety / hybrid of a crop needs to be assured for high nutrient use efficiency.

Annexure I

Fertilizer recommendations and N : P_2O_5 : K_2O ratios for different crops / cropping system in different agroclimatic zones of India

Sno.	Agroclimatic Zone	Soil	Crop/ Cropping System	N : P_2O_5 : K_2O Ratio	Fertilization recommendation (N - P_2O_5 - K_2O kg/ ha)
1.	Western Himalayas (J & K, H.P.)	Alluvial, Brown-hill	Rice (K)	4:2:1	120- 60-30
			Wheat	6:2:1	150-50-25
	Uttarakhand		Rice (R)	4:2:1	120-60-30
			Wheat	5:2:0	150-60-0
2.	Eastern Himalaya (Assam, W.B., NE states)	Alluvial, Brown hill, Red, *Tarai*	Rice (K)	4:2:2	80-40-40
			Rice (R)	4:2:2	80-40-40
3.	Lower Gangatic Plain (W.B.)	Alluvial Red Lateritic	Rice (K)	4:2:2	80-40-40
			Wheat	6:2:2	120-40-40
4.	Middle Gangetic Plain (Eastern U.P.)	Alluvial Red & Black	Rice (K)	4:2:2	120-60-60
			Wheat	4:2:1.3	120-60-40
			Sugarcane	4.5:1.5:1	180-60-40
	Bihar		Rice (K)	6:2:1	120-40-20
			Wheat	6:3:1	120-60-20
			Sugarcane	5:2.8:2	150-85-60
5.	Upper Gangetic Plain (Western U.P.)	Alluvial	Rice (K)	5:2:2	150-60-60
			Wheat	5:2:2	150-60-60
			Sugarcane	5:2:2	150-60-60
			Potato	6:2:3	180-60-90

Sno.	Agroclimatic Zone	Soil	Crop/ Cropping System	N : P_2O_5 : K_2O Ratio	Fertilization recommendation (N - P_2O_5 - K_2O kg/ ha)
6.	Trans Gangetic Plain (Punjab)	Alluvial	Rice (K)	4:1:1	120-30-30
			Wheat	4:2:1	120-60-30
			Sugarcane	5:2:2	150-60-60
			Cotton (Hybrid /Bt)	3:1:0	150-50-0
			G.hirsutum	2.5:1:0	75-30-0
			Mustard (R) (irrigated	7:2:1	100-30-15
	Haryana	Alluvial	Rice (K)	4:1:1	120-30-30
			Wheat (after Rice)	4:2:1	120-60-30
			P.millet (Hybrid)	4:2:0	120-60-0
			Wheat (after P. millet)	5:2.7:0	150-50-0
			Sugarcane	3:1:0	150-50-0
			Cotton (Hybrid/Bt)	5:2:2	150-60-60
			G.hirsutum	2:1:0	80-40-0
7	Eastern Plateau & Hills	Red & yellow, Red & lateritic, Mixed red & black			
	Chhatisgarh		Rice (K)	4:2:1-3	120-60-40
			Pulses (K)	1:3:1	20-60-20
	Jharkhand		Maize (K)	4:2:1	80-40-20
			Wheat	5:2:1	100-40-20
	Eastern Maharashtra (Bhandera region) & part of Orissa		Rice	4:2:1.3	120-60-40

Sno.	Agroclimatic Zone	Soil	Crop/ Cropping System	N : P_2O_5 : K_2O Ratio	Fertilization recommendation (N - P_2O_5 - K_2O kg/ ha)
8.	Central Plateau & Hills	Alluvial Shallow black			
	Madhya Pradesh		Soybean	1:3:1	20-60-20
			Wheat	4:2:1.3	120-60-40
	U.P. (Bundel Khand)		Wheat	4:3:1	80-60-20
	Maharashtra		Sorghum (K)	4:2:2	80-40-40
			Wheat	4:2:2	100-50-50
			Cotton (Hybrid/Bt)	4:2:2	100-50-50
			G.hirsutum	4:2:2	50-25-25
9.	Western Plateau (Maharashtra and Southern M.P.)	Black Reddish brown	Cotton (Hybrid/Bt)	4:2:2	100-50-50
			G.hirsutum	4:2:2	50-25-25
			Sugarcane	2.2:1:1	250-115-115
10	Southern Plateau	Red & Leteritic, Black, Alluvial			
	Andhra Pradesh		Rice (K)	4:2:2	120-60-60
			Rice (R)	4:2:2	120-60-60
			Sugarcane	0.9:0.8:1	112-100-120
			Cotton (Hybrid/Bt)	4:2:2	120-60-60
			G.herbaceum	4:2:2	90-45-45
			Sunflower (rainfed)	2:2:1	60-60-30
			Sunflower (irrigated)	2.5:3:1	75-90-30

Sno.	Agroclimatic Zone	Soil	Crop/ Cropping System	N : P_2O_5 : K_2O Ratio	Fertilization recommendation (N - P_2O_5 - K_2O kg/ ha)
	Karnataka		Rice (K)	3:1.5:1	120-60-40
			Sugarcane	1.3:0.4:1	250-75-190
			Cotton (hybrid/Bt)	4:2:2	120-60-60
			G.hirsutum	4:2:2	80-40-40
			G.hirsutum	4:2:2	40-20-20
			Sunflower (rainfed)	4:6:4	35-50-35
	Tamil Nadu		Rice (K)	4:2:2	120-60-60
			Rice (R)	5:2:2	150-60-60
			Sugarcane	3.5:1:2	225-60-120
			Cotton (Hybrid/Bt)	4:2:2	120-60-60
			G.hirsutam	4:2:2	80-40-40
			G.arboreum	4:2:2:	40-20-20
			Sunflower (Rainfed)	5:6:4	50-60-40
			Sunflower (irrigated)	4:6:4	60-90-60
11	East Coast Plains & Hills	Red, Black Coastal Alluvium			
	Orissa		Rice (K)	4:2:2	80-40-40
			Rice (R)	5:2.5:2	100-50-40
	Andhra Pradesh		Rice (K)	3:2:1	60-40-20
			Rice (R)	6:3:2	120-60-40
	Tamil Nadu		Rice (K)	5:2:2	125-50-50
			Rice (R)	5:2:2	150-60-60

Sno.	Agroclimatic Zone	Soil	Crop/ Cropping System	N : P_2O_5 : K_2O Ratio	Fertilization recommendation (N - P_2O_5 - K_2O kg/ ha)
12	West Coast Plains & Ghats	Red, Lateritic Coastal Alluvium			
	Kerala		Rice (K)	4:2:2	90-45-45
			Rice (R)	4:2:2	90-45-45
	Maharashtra (Konkan)		Rice (K)	4:2:1.3	120-60-40
			Rice (R)	4:2:1.3	120-60-40
13	Gujarat Plains & Hills	Red, Black	Groundnut (K)	1:1.6:0	15-25-0
			Wheat	4:2:0	120-60-0
	Northern Gujarat		Cotton (Hybrid/Bt)	4:2:0	150-80-0
			G.herbaceum	—	40-0-0
	Southern Gujarat		Cotton Hybrid/Bt	4.4:1:0	220-50-0
14	Western Dry Region (Rajasthan)	Reddish brown, Desert	Pearlmillet (K)	3:1:0	90-30-0
			Wheat	3:1:0	90-30-0
			Cotton (Hybrid/Bt)	7.5:2:1	150-40-20
			G.hirsutum	4:2:1	60-40-20
			Sugarcane	4:1.2:1.2	200-60-60
15	Island region (Andaman & Nicobar)	Coastal Alluvium salty	Rice (K)	4:2:1.3	120-60-40

[1] K = Kharif; R = Rabi (K – R make a two crops a year cropping system)

[2] 4:2:2 is used instead of 2:1:1 to permit comparison with 4:2:1. As far as possible all ratios are rounded up to whole numbers. Regions and crops, where K fertilization is not recommended may receive K application if indicated by soil test.

Source: PDCS, Modipuram for cropping system; For cotton, sugarcane pulses and oilseeds state recommendations and respective crop institutes / Directorate.

LIST OF PARTICIPANTS

1. Dr. Y.P. Abrol, Adjunct Prof. & INSA Honorary Scientist, Hamdard University, New Delhi
2. Dr. P.K. Batra, Head, Division of Design of Experiments, Indian Agril. Statistics Res. Institute, New Delhi
3. Dr. B.C. Biswas, Consultant, The Fertilizer Association of India, New Delhi
4. Prof. Ramesh Chand, ICAR National Professor, NCAP, New Delhi
5. Dr. P.K. Chhonkar, Former Head, Division of Soil Science, IARI, New Delhi
6. Dr. C. Devakumar, ADG (Education), ICAR, New Delhi
7. Dr. (Ms.) Vandana Dwivedi, Joint Advisor (Agricutlure), Planning Commission, Gov. of India, New Delhi
8. Dr. B.S. Dwivedi, Senior Scientist, Division of Soil Science, IARI, New Delhi
9. Dr. B. Gangiah, Divison of Agronomy, IARI, New Delhi
10. Dr. M.S. Gill, Director, Project Directorate of Cropping Systems Research, Modipuram
11. Dr. R.K. Gupta, Soil Scientist of National Food Security Mission, NSC, New Delhi
12. Dr. D.M. Hegde, Director, Directorate of Oilseeds Research, Hyderabad
13. Dr. H.K. Jain, Former Director, IARI and Vice-President NAAS, New Delhi
14. Dr. Rajender Parsad, National Fellow, IASRI, New Delhi
15. Dr. H. Pathak, Senior Scientist, Division of Environmental Sciences, IARI, New Delhi
16. Dr. P.S. Pathak, Former Director, IGFRI and Editor, NAAS, Lucknow
17. Dr. Rajendra Prasad, Former ICAR National Professor, IARI & INSA Hon. Scientst, New Delhi
18. Dr. A. Subba Rao, Director, IISS, Bhopal
19. Dr. M.S. Sachdev, Principal Scientist, Nuclear Research Laboratory, IARI, New Delhi
20. Dr. S.K. Sanyal, Director of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal
21. Dr. S.N. Sharma, Principal Scientist, Division of Agronomy, IARI, New Delhi
22. Dr. Y.S. Shivay, Senior Scientist, Division of Agronomy, IARI, New Delhi
23. Dr. A.K. Singh, DDG (NRM), ICAR, New Delhi
24. Dr. V.K. Singh, Senior Scientist, PDCSR, Modipuram
25. Dr. C. Srinivasarao, Principal Scientist, CRIDA, Hyderabad
26. Dr. Anand Swarup, Head, Div. of Soil Science & Agril. Chemistry, IARI, New Delhi
27. Dr. R.K. Tewatia, Chief (AS), The Fertilizer Association of India, New Delhi
28. Dr. M.V. Venugopalan, Principal Scientist, Central Institute of Cotton Research, Nagpur
29. Dr. R.L. Yadav, Director, Indian Institute of Sugarcane Research, Lucknow
30. Dr. J.S.P. Yadav, Former Chairman, ASRB, New Delhi