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LOW AND DECLINING CROP RESPONSE TO FERTILIZERS

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PREAMBLE

With an annual compound population growth rate estimated at 1.97%, nearly 20 million new mouths equivalent to the present population of Australia are added to India each year. Providing two meals a day to its people will always remain one of the major concerns of the Government. Foodgrain demand of India is estimated at about 300 million tonnes per annum by 2020, necessitating an increase of about 91 million tonnes (Mt) from the estimated 209 Mt production for 2005-06. Since there is no likely prospect of any further increase in the area under cultivation over the present 142 million hectares, much of the desired increase in foodgrain production has to be attained by enhancing the productivity per unit area. The productivity of rice has to be increased from the present 2077 kg/ha to 2895 kg/ha by 2020 with an average increase of about 5% per annum. The productivity of wheat has to be increased from the present 2713 kg/ha to 3918 kg/ha with an average increase of about 7.5% per annum, while the productivity of pulses has to be increased from the present 637 kg/ha to 1282 kg/ha with an average increase of about 5.3% per annum. On the contrary, the productivity of most foodgrain crops except wheat has shown a negative growth rate of 0.72 to 1.84% per annum during the period 2000-01 to 2002-03. This poses not only a matter of great concern but also a formidable challenge.

The foodgrain production, following the green revolution in 1969-70, was 99.5 Mt and nearly doubled by the end of the last century. The highest average annual increase of 6.1% in foodgrain production was recorded during 1980's; from 110 Mt in 1979-80 to 171 Mt in 1989-90, but the annual increase in foodgrain production during 1990s dropped to 1.5%. The fact that the fertilizer was the key input in augmenting foodgrain production after the availability of the seeds of high yielding crop varieties, is evident from the increase in fertilizer ($N + P_2O_5 + K_2O$) consumption from 1.98 Mt in 1969-70 to 18.07 Mt by 1999-00. Nevertheless, the average annual increase in fertilizer consumption witnessed a declining trend in these three decades, as reflected by 16.5% during 1970's, 12.04% during 1980's and only 5.6% during 1990's.

A simple regression analysis between the foodgrain production and fertilizer consumption during 1960-61 to 1999-00 showed that the partial factor productivity of fertilizers has been continuously declining. The data available from some centres under the Project Directorate of Cropping Systems Research (PDCSR), Modipuram also indicate a reduction in crop response to fertilizer application, specially when balanced fertilization is not practiced. This is supported by the fact that the farmers in the rice-wheat cropping system belt (specially Punjab, Haryana

and Western U.P.) are forced to apply more and more fertilizer to obtain the same crop yields as in the preceding years. The data from the trials on the farmers' fields conducted by the PDCSR, Modipuram during 1999-2003 showed that the average response of cereals to fertilizer was 8-9 kg grain/kg fertilizer. The efficiency of fertilizer nitrogen is only 30-40% in rice and 50-60% in other cereals, while the efficiency of fertilizer phosphorus is 15-20% in most crops. The efficiency of K is 60-80%, while that for S is 8-12%. As regards the micronutirents, the efficiency of most of them is below 5%. Attention to this serious problem of low and declining crop response to fertilizer was drawn by Professor M.S.Swaminathan, President, NAAS in his Presidential address on 5th June 2005.

In view of the above disturbing agricultural scenario, a two-day Brain Storming Session on "Low and Declining Response of Crops to Fertilizers" was organized by the National Academy of Agricultural Sciences at New Delhi on 20th and 21st February 2006 with Dr. Rajendra Prasad, Ex ICAR National Professor and Ex INSA Sr. Scientist as the Convener. It was attended by 41 experts including some of the Directors of leading National Agricultural Institutes and Professors/Scientists/Officials of the State Agricultural Universities/ Ministry of Agriculture/FAI etc.

The deliberations included four technical sessions with key and panelist presentations followed by discussion. Dr. R.B. Singh, Member, NCF, GOI in his inaugural address emphasized the need for soil health card, and increasing the farm profit by improving the crop response to fertilizers. Dr. J.S.P. Yadav, former Chairman, ASRB in the wrap up/concluding session listed several causes of declining/low crop response to fertilizers and summarized recommendations made thereof.

It was vividly brought out in the deliberations that the major factor responsible for the low and declining crop response to the fertilizers was the continuous nutrient mining of the Indian soils without adequate replenishment to the desired extent. It is estimated that about 28 Mt of primary plant nutrients are removed annually by crops in India, while only 18 Mt or even less are applied as fertilizer, leaving a net negative balance of about 10 Mt of primary plant nutrients (NPK).

An analysis of the data pertaining to rice-wheat cropping system from 24 research stations in the Indo-Gangetic plains revealed that the rice yields are declining more rapidly as compared to wheat yields, and soil K depletion seemed to be a general cause, whereas P and Zn depletion emerged as a cause at some centres. Similarly, a study at ND University of Agriculture and Technology, Faizabad showed that the yield decline in both rice and wheat was the highest when N alone was applied at 120 kg/ha. As the depletion of native soil P increased with time, the response of both rice and wheat to applied P showed an increase after 10 years of cropping. Also, as the native soil K decreased over time, the response to applied K started to increase after 5 years in both rice and wheat. In wheat, it continued to increase even after 20 years, while in rice the increase in response to K stopped after 15 years. Such reports are several in number.

Furthermore, the soils are also getting continuously depleted of secondary plant nutrient S and micronutrients. The marked deficiencies of S and Zn are widespread in the country and significant responses to application of these nutrients are well documented. The deficiencies of B, Fe and Mn are also being reported from some parts of the country. Thus, inadequate and imbalanced fertilization is a major causative factor for low and declining crop response to fertilizers. The need for integrated nutrient management including the use of organic sources such as farmyard manure, rural and urban compost, vermi-compost, green manures, inclusion of legumes in the crop rotations, growing of dual purpose short duration legumes such as mungbean in the summer months in the rice-wheat cropping system, and bio-fertilizers was emphasized for meeting a part of the plant nutrient needs of crops.

The major factor, responsible for the low response of crops to fertilizer nitrogen, is its low use-efficiency, especially in case of rice crop where it is only 30-40% of applied N due to various N loss mechanisms, namely, surface run-off, ammonia volatilization, leaching and denitrification. In 1995, the global estimate of nitrogen loss, from the applied fertilizer N in 1995 through ammonia volatilization was 11.2 Mt (14.45 %), while that through NO and N_2O through denitrification was 1.5 Mt (1%). India's contribution to these losses could approximately be 10% of the total. Ammonia added to the atmosphere leads to the acid rain, while NO and N_2O are responsible for the depletion of ozone layer in the atmosphere. In addition, nitrates leach to the groundwater and lead to the nitrate pollution of drinking water which is injurious to health. An increase in the nitrate content due to heavy N fertilization has been reported in Punjab by the researchers at the Punjab Agricultural University. There is, therefore, an urgent need to develop more efficient nitrogen fertilizers.

Some slow-release N fertilizers developed in the foreign countries are used on a limited scale in case of high value crops due to their high costs. Similarly, nitrification inhibitors have also been developed in some foreign countries as well in India, but their high cost and application problems with some, such as N-serve, are constraints to their use. Studies in India showed that coating urea with neem cake/oil/neem bitterns could retard the nitrification for 2-3 weeks. A technology for coating urea with neem oil emulsion at the factory scale is now available in India and the Govt. of India has permitted National Fertilizers Limited (NFL), Shriram Fertilizers and Chemicals and Indo-Gulf Fertilizers to manufacture and market the neem-coated urea on an experimental basis. The results obtained with neem-coated urea on the farmers fields have shown a 2 to 10 % higher grain yield of rice as compared to uncoated urea. Taking a mean value of 5% increase in nitrogen use-efficiency, a saving of 5 lakh tonnes of nitrogen per annum at the current level of consumption of 10 Mt of N is estimated, which is equivalent to the combined annual production of fertilizer N at Panipat and Bhatinda plants of NFL or the annual production of fertilizer N at Jagdishpur plant of Indo-Gulf. There is a heavy demand of neem-coated urea in several states of India, and therefore, production of neem-coated urea needs to be enhanced.

RECOMMENDATIONS

Major recommendations emanating from the Brainstorming Session are given here under four heads, namely (A) causes for low and declining crop response to fertilizers, (B) agenda for research, (C) rejuvenation of agricultural extension, and (D) policy decisions.

A. Causes for Low and Declining Crop Response to Fertilizers

- *Nutrient Supply and Soil fertility*
- Continuous use of fertilizer N alone or with inadequate P and K application leading to mining of native soil P and K
- Continued practice of intensive cropping systems like 'rice-wheat' with high yielding varieties even under recommended NPK use, impoverishing soils of secondary and micro nutrients specially S, Zn, Mn, B and Fe
- Use of high analysis fertilizers and inadequate addition of organic manures resulting in widespread deficiencies of S and micronutrients
- Fertilizer application mostly not based on soil-test values
- Inappropriate time and method of fertilizer application
- Excessive use of irrigation in rice-wheat cropping system, sugarcane and other heavily fertilized crops leading to leaching of nitrogen and other plant nutrients
- Inadequate availability of appropriate kind of fertilizers at the right time
- Antagonistic reaction between some plant nutrients
- Low status of soil organic carbon
- Subsoil impedance to plant root system restricting nutrient uptake
- Soil degradation due to high salinity/sodicity/acidity/waterlogging, affecting nutrient availability
- Lack of adequate and quality soil testing facilities and meager availability of fertilizer recommendations under aberrant weather conditions
- Environmental degradation, having negative impact on belowground biodiversity, especially agriculturally important microorganisms

❖ *Seed*

- Non-availability of sufficient seeds of high yielding varieties of crops at affordable price and at the appropriate time
- Lack of more efficient nutrient using genotypes

❖ *Agronomic Practices*

- Delayed sowings / plantings
- Low seed rates resulting in poor crop stands
- Poor weed management
- Inefficient tillage
- Inefficient irrigation and rainwater management
- Large scale monoculture
- Lack of consideration of previous cropping in the same field
- Lack of capturing water-nutrient synergic interaction
- Inadequate plant protection

❖ *Weather Aberrations*

- High intensity rain leading to nutrient loss
- Abnormal high/low temperature

B. Agenda for Research

- Nutrient budgeting in different crops/cropping system for different agro-ecological zones needs to be done.
- Site-specific fertilizer application practices (SSFAP) based on soil-test recommendations need to be developed for various crops and cropping systems in different agro-ecological zones of the country.
- For sustainable agriculture, integrated plant nutrient supply systems (IPNS), involving FYM, compost, vermicompost, green manures, dual purpose legumes (e.g. summer mung in rice-wheat cropping system) and biofertilizers, need to be

developed for various crops and cropping systems in different agro-ecological zones of the country.

- SSFAP and IPNS also need to be developed for different agro-forestry systems, integrated farming, orchards and peri-urban-agricultural systems involving vegetables and flowers.
- Fertilizer - irrigation water interaction studies need to be intensified.
- Considering the fact that about 40-50% of the applied fertilizer nitrogen is not only lost from the soil-plant system, but also adds to the environmental pollution, more efficient nitrogen fertilizers, involving materials such as neem oil or cake or indigenously developed nitrification inhibitors need to be developed for field adoption.
- Customized fertilizers based on soil-test-crop response studies for different regions of the country are to be developed.
- Research is needed on the use of soluble fertilizers/fertilizer solutions specially in horticulture, vegetable crops and floriculture for drip irrigation system.
- Since fertilizer nitrogen is used in the largest amounts and its efficiency is low, development of accurate and site-specific recommendations for nitrogen based on soil-test, plant-tissue analysis, use of chlorophyll meter and other techniques, if any, is urgently needed.
- Appropriate fertilizer recommendations for different crops grown in the dryland areas need to be developed vis-à-vis weather aberrations.
- There is need for developing a data base at IASRI, New Delhi for all the field experiments conducted on crop response to fertilizers in the country. IASRI should develop a suitable proforma for reporting of such data, which the ICAR should circulate to all agricultural universities and ICAR/State Institutions for compliance.
- The optimum doses of N, P and K need not be computed from the response curves. These need to be computed by fitting response surfaces and using soil fertility status.

C. Rejuvenating Agricultural Extension

- It is generally presumed that the farmers know all about fertilizers. This is a myth that needs to be broken. One of the major constraints is the farmers' lack of awareness about the concept of balanced fertilization not only about major elements but also involving secondary and micronutrients.

- Extension machinery needs to be geared up and rejuvenated/ revived.
- Demonstrations are needed to emphasize the need for balanced fertilization of N,P,K,S Zn, B, Fe and other micronutrients and on Integrated Plant Nutrient Supply System (IPNS).
- Demonstrations on the role of fertilizers for increasing crop yields under dryland agriculture conditions are also needed.
- The farmers need to be educated about the role of micronutrient plant nutrients in human and animal health. This will encourage the application of micronutrients in crop production.
- Demonstrations are also needed to emphasize on the time and method of fertilizer application.
- The fertilizer industry should play an active role in conducting demonstrations in respect of the balanced fertilization, IPN, as well as on time and method of fertilizer application.

D. Policy Decisions

A long-term pragmatic policy for all fertilizer nutrients including secondary and micronutrients is essential to achieve balanced nutrition to overcome soil fertility and health degradation, and improve crop productivity on a sustainable basis. This includes:

- Adequate number of well equipped soil-testing laboratories manned by well trained personnel to take care of secondary and micronutrient analysis
- Soil health cards for all the categories of the farmers throughout the country for the purpose of periodical monitoring of soil fertility status and as one of the sources for obtaining agricultural credit
- Quality control for fertilizers including micronutrient fertilizers
- Standardization of organic manures
- Providing price incentives to the fertilizer manufacturers opting for the manufacture of value-added fertilizers such as neem-coated urea and balanced customized fertilizers
- Strengthening collaboration between the fertilizer industry and National Institutes engaged in developing soil test-based and site-specific nutrient recommendations to develop soil and crop specific quality fertilizers

- Provision of a transparent regulatory framework for ensuring supply of tailor-made crop and soil-specific quality fertilizers to the farmers and corresponding provisions in the Fertilizer (Control) Order, GOI
- More proactive State Fertilizer Review Committees having wider representation of the scientists and the industry and empowered with quality control for blended and value added fertilizers
- Ensuring credit to the farmers at low interest rates for the purchase of fertilizer, seed, pesticides, and agricultural equipment
- Providing subsidies to promote cultivation of legume crops for green manuring/ grain to build-up soil fertility and to meet the shortage of pulse requirements in the Country
- Establishment of a *National Network on Integrated Fertilizer Development for Sustainable Agriculture* by the ICAR/Ministry of Agriculture
- Establishment of Co-ordination Cell for co-ordinating the activities of different ministries of Govt. of India related to efficient use of fertilizers such as Ministry of Agriculture, Ministry of Fertilizers & Chemicals, Ministry of Irrigation, I.C.A.R. and National Commission for Farmers.

CONCLUSION

Fertilizer has been and will continue to be the key input for achieving the estimated foodgrain production goals of the country. Since increase in foodgrain production is possible only through the increased productivity per unit land, an all out effort is needed to increase the crop response to fertilizers. Some of the suggested measures are balanced and adequate N,P,K,S, Zn, B and Fe (and any other deficient nutrient) fertilization, Integrated Plant Nutrient Supply System (IPNS), development of quality soil-test facilities at district/block level, timely availability of desired fertilizer materials, availability of good quality seed of the recommended crop varieties, implementation of recommended agronomic practices and availability of low interest credit to the farmers. Considering the fact that about 40-50% of the applied fertilizer nitrogen is lost by ammonia volatilization, leaching, run-off and denitrification, development of more efficient nitrogen fertilizers such as neem-coated urea needs to be encouraged by providing price incentive to the fertilizer manufacturers. Customized soil and crop specific fertilizer materials need to be developed for major cropping and farming systems in different agro-eco regions. Creation of a National Network on Integrated Fertilizer Development for Sustainable Agriculture is urgently needed.

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NAAS Documents on Policy Issues*

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2.	Fertilizer Policy Issues (2000-2025)	- 1997
3.	Harnessing and Management of Water Resources for Enhancing Agricultural Production in the Eastern Region	- 1998
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