

EXECUTIVE SUMMARY

Background

It is to be noted here that the all-India averages of K fertilizers are distinctly lower than that of averages of east zone (which includes Bihar also) in all the three years. Data related to all-India scenario suggests a remarkable increase (nearly 1.61 times) in consumption of nitrogenous fertilizers during the recent three years' period of 2010-11 to 2012-13. It was 86.15 kg/ha in the year 2010-11 that went up to 139.67 kg/ha in 2012-13. This was quite higher than the average of east zone. In regard to consumption of phosphatic fertilizers (taken as all-India average), it declined consecutively during the period. It declined from 41.88 kg/ha of 2010-11 to 33.44 kg/ha in 2012-13. It was also quite lower in comparison to east zone in the last year. A consecutive decline in use of potassic (K) fertilizers is also expressed.

There are concerns about the indiscriminate use of chemical fertilizers by farmers with a view to increase the crop yield. This has led to deterioration of soil structure, wastage of nutrients, destruction of soil microorganisms and scorching of plants at the extreme cases. A combination of factors such as intensive cultivation of crops, differential pricing of fertilizers and subsidy, might have contributed to excessive use of fertilizers by the farmers. At the same time, it is reported that many parts of India have shown deficiency of not only primary nutrients (N, P, K) but also secondary (Sulphur, Calcium and Magnesium) and micro nutrients (Boron, Zinc, Copper and Iron). Government of India had undertaken initiatives to ameliorate the situation and encourage the farmers for balanced use of fertilizers. These initiatives among others, included decontrol of phosphatic and potassic fertilizers, promotion of integrated nutrient management, production and promotion of organic manures and bio-fertilizers, National Project on Management of Soil Health and Fertility (NPMSF), and Nutrient Based Subsidy (NBS) policy. Attempts have also been made to strengthen and revamp soil testing laboratories in various districts under NPMSF. Farmers are encouraged to test their soil periodically and apply fertilizers based on the deficiency of nutrients in soil. This is intended to ensure balanced supply of nutrients for maintaining soil health and improving crop productivity.

In the light of increased degradation of natural resources due to intensive cultivation and injudicious use, their sustainable management holds the key for ensuring sustainable food production. Due to lack of awareness among the farmers, there are wide spread problems related to the indiscriminate use of chemical fertilizers, mismanagement of surface water and over exploitation of ground water. The over use of chemical fertilizers in most parts of India for nutrient management in farming in the last few decades led to several problems affecting soil health, nutrient flow

and natural environment. There is a need for promoting, among others, balanced use of fertilizers for increasing productivity of crops and for better absorption of nutrients from the applied fertilizers.

It is suggested that farmers should go for regular soil testing and use recommended doses of fertilizers as advised by the agricultural scientists. In this connection, Task Force on Balanced use of Fertilizer recommended formulating a Centrally Sponsored Scheme entitled “*National Project on Management of Soil Health and Fertility (NPMSE)*.” Accordingly, this scheme has been implemented since 2008-09 and it encompasses three components viz., (i) strengthening of soil testing laboratories (STLs), (ii) promoting use of integrated nutrient management, and; (iii) strengthening of fertilizer quality control laboratories. There is no systematic study undertaken so far for evaluating the effectiveness of the programme on crop productivity, extent of soil testing for nutrient deficiency and adoption of recommended doses of fertilizers by farmers based on the soil tests. Therefore, the present study examines the level of adoption and constraints in the application of recommended doses of fertilizers, impact on crop productivity and relevant institutional problems prevailing in the state of Bihar, with following **objectives**:

- i. *To examine the level of adoption and its constraints in the application of recommended doses of fertilizers based on soil test reports by the farmers, and;*
- ii. *To analyze the impact of adoption of recommended doses of fertilizers on crop productivity and income of farmers.*

Data and Methodology

The present study is based on primary data collected from Bihar. The reference period for the study is 2013-14. At the first stage, two major crops in terms of area, i.e., rice and wheat, have been selected from Bihar. At the second stage, for each crop, two districts, namely East Champaran and Rohtas have been selected based on the crop area share (CAS) within the state. The area under paddy in East Champaran is estimated at 5.80 per cent and that in Rohtas district, it was 5.10 per cent of the total area under paddy in the state. These comprised quite larger area shares in the state as a whole. Similarly, in case of wheat also, CASs in Rohtas and East Champaran districts were higher estimated at 6.70 per cent and 5.20 per cent respectively.

At the third stage, from each district, two blocks have been selected again based on CAS itself. Thus, from East Champaran district, two blocks namely (i) Motihari, and; (ii) Kalyanpur were selected. In Rohtas district, the two selected blocks on the same basis were (i) Kargahar, and; (ii) Dinara.

At the fourth stage, from the selected blocks, two clusters of villages comprising 3-4 villages per cluster have been selected for conducting the survey. It is to be noted here that Motihari block was selected for paddy and Kalyanpur block for wheat. Two cluster of villages selected under Motihari block were (i) Bhataha, and; Baswariya. In Kalyanpur block of East Champaran district, cluster of villages selected comprised (i) Tenua, and; (ii) Parsauni. Selection of Kargahar block in Rohtas district was meant for paddy and that of Dinara for wheat. Cluster of villages (COVs) selected for detail study in Kargahar block of Rohtas district are (i) Basdiha, and; (ii) Semari and the same under Dinara block were (i) Akhodha, and; (ii) Bisikwan.

At the fifth stage, a sample of 60 soil test farmers per crop were selected randomly from each district for assessing the application of recommended dose of fertilizers and its impact on crop production. The cluster approach was followed to ensure that adequate number of soil test farmers could be available for survey. Further, desired care was taken to ensure that the selected villages fell under the agro-climatic conditions of sample districts and that they could have certain common characteristics, such as (i) soil type, (ii) irrigation, and; (iii) crop variety.

At the sixth stage, 30 controls (non-soil-test farmers) have also been involved for each reference crop from each district selected purposively from the chosen cluster itself for differentiating the effect of the application of recommended dose of fertilizers on crop productivity and income.

In this way, a total of 120 soil test farmers and 60 control farmers for each crop (i.e., rice and wheat) in each of the two selected districts were interviewed. The sample farmers were classified into different farm size groups post survey as per the size of net operated area (NOA). *The soil test reports of the soil samples taken in 2013 couldn't be made available in hard copies (though it was mandated) to the farmers of the selected districts by the 1st week of July, 2014. So, the application of recommended doses of fertilizers and its impact on crop productivity and income of farmers could not be examined.*

Trend in Fertilizer Consumption

Fertilizer consumption in Bihar was a mere 22 kg NPK/ha in TE 1982, which increased to 63 kg/ha in TE 1991 and reached a level of 82 kg/ha in TE 1998. Fertilizer consumption increased in all the zones during this period. It may be noted that growth in fertilizer consumption slackened in the 1990s as compared to the 1980s. There was wide variation in the level of its use across zones/districts. It was as high as 104 kg/ha in Zone-III and 69 kg/ha in Zone-I in TE 1998. Total consumption of chemical fertilizers in Bihar was 731.60 thousand MT during 2004-05. The level of consumption has increased to 1064.80 thousand MT during 2006-07.

During the last five years' period of 2009-10 to 2013-14, fertilizer consumption in Bihar has remained quite higher than all India average and in regard to the uses of NPK fertilizers individually also. A quick look on data containing consumption of Nitrogen (N), Phosphatic (P) and Potassic (K) fertilizers distinctly reveal higher quantities in case of Bihar than that of all-India average during the three years' period of 2011-12 to 2013-14 except phosphatic (P) fertilizers in the years 2011-12 and 2013-14. It's all India average consumption quantities were a bit higher than that of Bihar (40.54, 28.85, 38.84 & 27.44 kg/ha) respectively.

In aggregate sense, means N, P, K taken together, Bihar consumed higher quantities of fertilizer (kg/ha) in the five years i.e., 2009-10 to 2013-14, which were estimated at 165, 175, 180.48, 199.66 and 164.87, when compared with all India averages i.e., 140, 145, 142.33, 130.79 and 125.39 respectively.

The consumption of nutrients meant for all the major crops taken together was 61.20 kg/ha in 1993-94 that went on increasing continuously till the year 2006-07 (125 kg/ha) except a decline of 8.50 kg/ha in the year 2003-04 over preceding year's consumption of 96 kg/ha. Some declines in consumption of fertilizers in regard to kharif, rabi and total crops could be seen during the last two years, i.e., in 2012-13 and 2013-14 in Bihar.

The total quantities of NPK fertilizers (taken together) also declined by 18.82 per cent and 16.45 per cent during kharif and rabi seasons in the year 2013-14 in comparison to previous year 2012-13

As far the quantities of consumption of fertilizer in kg/ha in the state in growing kharif and rabi crops during the years 2012-13 and 2013-14 are concerned, these declined by 19.78 per cent, 17.15 per cent and 18.26 per cent in comparison to the preceding year i.e., 2012-13 respectively in regard to kharif, rabi and total of both crops. The quantities of fertilizer use in case of kharif and rabi crops and for the crops taken together in 2013-14 were noted as 127.17 kg/ha, 171.50 kg/ha and 150.20 kg/ha respectively.

Socio-Economic Characteristics of Sample Households

Out of the total 'soil test farmers (STFs)' and 'control farmers (CFs)' surveyed in both the districts (i.e., East Champaran & Rohtas) for paddy crop, highest percentage of households (56.66%) belonged to marginal category under control group. In case of wheat, medium farm households under STFs category were found to have dominated (40.00%) over other farm size classes and control group (CG) too. Marginal and Small farm households involved in paddy growing including STFs & CFs comprised 23.89 per cent and 21.11 per cent respectively. In regard to wheat

growing surveyed farm households belonging to both STFs & CFs, medium and small farmers were more (36.67% & 27.22%) respectively.

Agriculture being the main occupation for STFs and control farmers CFs meant for both surveyed households of paddy and wheat (100%, 100%, 99% and 100%) respectively dominance of male (88.89%) and 100% on overall level), average years of experience in farming estimated at 25.10 and 24.20 respectively at overall level inscribe that surveyed farm households had been associated with agricultural activities for nearly half of their average ages.

The average size of owned land, leased out, uncultivated/fallow, NOA, NIA, GCA, and CI (7.53 acres/household, 0.06 acre, Hh, 0.05 acre/Hh, 7.76 acres/Hh, 7.10 acres/Hh, 15.02 acres/Hh and 193.56%) respectively meant for soil test farmers (STFs) surveyed for paddy crop were as per the normal belief, greater than that of control farmers (CFs).

As far operational land holding of the sample households surveyed for wheat crop is concerned, the data suggest to conceptualize that STFs were, unlike paddy, slightly better placed in regard to owned land, leased in, leased out, NOA, NIA, GCA and CI (6.38, 0.31, 0.10, 6.59, 6.29, 13.00 acres/household and 197.16%) respectively.

It is distinctly revealed that canal had been the most prominent source of irrigation for both STFs and Control farmers (CFS) in case of paddy (50% & 46.87%) respectively. Bore well remained the most important source of irrigation for both STFs and CFs (59.17% & 51.03%) respectively meant for surveyed Hhs of wheat area.

In case of sample Hhs of paddy areas, paddy, wheat and orchard (litchi, mango, etc.) were the main crops occupying larger areas on overall level during kharif, rabi and annual/perennial seasons (48.78%, 37.62% & 0.69%) respectively. In regard to crop - II (wheat) areas sample Hhs, again paddy and wheat were prominently grown during kharif and rabi seasons (42.01% & 41.91%).

It is interesting to note that both the STFs and CFs surveyed in the paddy and wheat growing areas used HYV kharif paddy and wheat (rabi) as major crops having devoted larger percentages of cropped area (18.70, 10.50, 10.00, 11.12 and 8.50, 10.00, 5.10, 7.35) respectively.

It is revealed that in regard to value of output and value of output sold by both STFs and CFs of paddy growing Hhs, large size farm Hhs remained ahead (Rs. 1,95,580/Hh, Rs. 17,780/acre, Rs. 1,64, 062.50, Rs. 15,625, value of output sold Rs. 1,36,906, Rs. 12,446, Rs. 1,14,843.75, and Rs. 10,937.50) respectively.

Having paid attention on the data in the table comprising value of output, and value of output sold by the surveyed Hhs of wheat area, again it is evident that large farm Hhs were ahead of all other farm size groups except CFs, whose value of output sold was highest in case of medium farmers (Rs. 13,050/acre). It is further noticed that farm size is directly related to value of output, and value of output sold in positive way in case of both STFs and CFs meant for both the crops.

It is evident that STFs did own higher number of high priced farm implements/equipments than that of CFs. STFs were well ahead in regard to possessing tractor/trolley, electric motor/diesel engine and manual/power sprayer than that of CFs applicable for both paddy and wheat growing farm Hhs (0.42/Hh, 0.67/Hh, 0.33, for CFs these were 0.21, 0.22, 0.12 and for wheat STFs, these were 0.48/Hh, 0.58/Hh, 0.23 and in case of CFs, 0.20/Hh, 0.20/Hh, 0.08/Hh) respectively.

STFs did have higher agricultural credit by commercial banks as reported by both paddy and wheat growing surveyed households (Rs. 833.33 and Rs. 2166.67) respectively. For CFs of paddy and wheat crops, the most instrumental sources of credit remained friends/relatives and commercial banks in case of wheat growing farm households only (Rs. 1783.33/Hh and Rs. 3,017/Hh) respectively.

In case of sample farmers of wheat area, CFs were again found to have outstanding amounts from friends/relatives apart from commercial banks (Rs. 830 380/Hh), the STFs had outstanding of Rs. 416.67/Hh by friends/relatives

As most of the CFs belonging to both paddy and wheat growing areas were resource poor (RP) in comparison to STFs, so CFs had higher credit outstanding on them than that of STFs (Rs. 2,616.66, Rs. 3,847, in comparison to Rs. 1,883.33 and Rs. 2,583.34/Hh for STFs) respectively. In percentage terms, higher agricultural credit outstanding meant for STFs of paddy and wheat areas and CFs of wheat areas only was found (4.17, 5.00 & 13.33) respectively.

It is interesting to note that CFs remained much ahead in availing agricultural loan for seasonal crop cultivation, purchase of tractor and other implements, purchase of livestock and land development (taken together) for both paddy and wheat growing areas than the STFs. The percentages of the purpose of agricultural loan were (70.00, 91.67, 57.77 and 72.50) respectively on taking it in totality for agriculture and allied purposes).

Details of Soil Testing and Recommended Doses of Fertilizers

While higher coverage of net operated area (NOA) was visible in case of surveyed households of wheat growing area than that of paddy farm households (59.33% & 43.34%) respectively, the average area covered under soil test in wheat area was little higher than that of paddy farmers (3.91 and 3.52 acres) respectively. Farm class wise

analysis reveals that marginal farm households belonging to both paddy and wheat areas were ahead in regard to areas covered as percentage to NOA (61.73 & 65.79) respectively.

State department and friend/neighbours were the main sources of information about soil testing by STFs of both paddy and wheat growing areas. In both cases, while large farmers got information from the agencies of state department, marginal and small farm households could come to know from friend/neighbours (95.45%, 100.00%, 22.22% & 30.00%) respectively.

Increasing crop yield, motivation from village demonstration/training/exposure visits and adopt new technological practices were the prominent reasons for soil testing by STFs on overall level, while very few of the sample households total 'peer farmers' group pressure' to be instrumental (100.00%, 90.83%, 57.50% & 50.00%) respectively.

There are sufficient data to find for the fact that (i) soil testing laboratories were located far away, (ii) lack of knowledge about taking soil samples, (iii) No knowledge about whom to contact for details on testing, and; (iv) lengthy process and no awareness were the main reasons for not testing soil during the last three years meant for paddy and wheat crops separately (88.33%, 70.00%, 91.67%, 15.67% & 81.67% and 63.33%, 98.33%, & 41.67%) respectively.

Adoption of Recommended Doses of Fertilizers and its Constraints

Farm class wise data reveal that marginal, small and large STFs growing paddy used maximum quantities of Urea, DAP & Potash (100 kg/acre, 50 kg/acre and 7.03 kg/acre) respectively. In case of CFs, small, medium and large farm households were ahead in using these fertilizers (102, 50.25 and 1.38 kg/acre) respectively.

Having viewed in totality, urea was used in larger quantities followed by DAP and Potash in regard to both STFs and CFs (90.55 kg/acre, 45.53 kg/acre, 3.14 kg/acre and 98.98 kg/acre, 49.13 kg/acre and 0.29 kg/acre) respectively. Small, small large and large STF households and small, medium, large and large again belonging to CFs used higher quantities of Urea, DAP, SSP and Potash in kg/acre (100.01, 62.33, 3.45 and 8.50) respectively in case of STFs and 101.00, 51.03, 2.21 and 5.11 kg/acre respectively meant for CFs.

It is interesting to note that both the STFs and CFs belonging to sample households of paddy and wheat growing areas applied broadcasting method (100.00%) for every of the chemical fertilizers, viz., urea, DAP, SSP & potash.

Only Farm Yard Manure (FYM) and Green Manure (GM) were found to have been used by STFs and CFs growing paddy and FYM and vermi-compost/bio-gas waste (VC/BGW) by wheat growing STFs and CFs.

Maximum quantities and area coverages of FYM by paddy growing STFs and CFs (1471.86 kg/acre, 25.05 % and 1415.38 kg/acre, 40.00%) respectively were observed. In case of wheat growing STFs and CFs, these figures were 469.10 kg/acre, 48.10% and 473.13 kg/acre, 25.82% respectively. Both paddy and wheat growing STFs were much ahead (in percentage terms) than that of CFs in regard to applying FYM.

Private fertilizers shops/Dealers (PFS/D) were the main source for majority of the STF farm households growing paddy (72.50%), who purchased fertilizers from this source. When viewed in totality (i.e., including marginal, small, medium and large farmers), Company Authorized Dealers (CADs) were used by 27.50 per cent of the farm households. Control farmers (CFs) of paddy growing areas in majority used PFS/D source (73.33%) and CAD (26.67%). The two sources, namely: PFS/D and CADs were prominently used by wheat growing STFs and CFs belonging to all farm size classes on overall level (52.50%, 47.50%, 51.67% and 48.33%) respectively. Across the farm size, marginal and large STFs used PFS/D and CADs as main sources for purchasing fertilizers (65% and 61.54%) respectively. In case of CFs also, similar scenario were observed in regard to purchase of fertilizers (58.33% and 57.14%) respectively.

PFS/D sources were the most important sources for both paddy and wheat growing STFs and CFs, from which fertilizers, like: Urea, DAP, SSP and Potash were purchased. Much lower quantities (in percentage terms) of Urea, DAP, SSP and Potash were purchased by both paddy and wheat growing STFs and CFs from CADs. In case of both STFs and CFs growing wheat CADs were the main source, from where farmers purchased maximum quantities of fertilizers.

It is revealed that among STFs, average prices of urea, DAP and potash (Rs. 7.29/kg, Rs. 25.96/kg and Rs. 16.81/kg) respectively were a little higher than that of CFs (Rs. 6.83/kg, Rs. 25.50/kg and Rs. 14.52/kg) respectively. But, in regard to transportation cost, these were higher in case of CFs except SSP (Rs. 0.53/kg, Rs. 0.41/kg and Rs. 0.63/kg) respectively.

Impact of Adoption of Recommended Doses of Fertilizers

Highest average yields (in qtl/acre) by STFs and CFs belonging to medium and large farm size groups meant for both paddy and wheat crops (14.00, 14.00, 12.40, 12.50 & 14.50, 15.00, 12.00 and 12.25 qtls/acre) respectively are delineated. Percentage differences in yield (in regard to average yield and average values of output) were

also found higher among medium and large farm households than that of marginal and small ones in case of both the crops.

Average values of output (Rs./acre) were found clearly higher in case of medium and large categories of both STFs and CFs meant for paddy and wheat crops separately (17500, 17780, 15624, 15625 and 21025, 21750, 17400 & 17762.50) respectively.

Policy Recommendations

1. Soil testing laboratories (STLs) at the district levels lack adequate staff that resulted in to non-distribution of soil health cards to the farmers in hard copies. So, there should be full proof arrangement to distribute the same immediately after the results are brought out (*Directorate of Soil Testing, Dept. of Agriculture, GoB*).
2. Required inputs at the STLs should be made available in time. (*Directorate of Soil Testing, Department of Agriculture, GoB*).
3. To expedite the soil testing exercises for all farmers in time, mobile soil testing vans should be deployed (*Directorate of Soil Testing, Department of Agriculture, GoB*).
4. At present, soil testing is made for primary nutrients (NPK) only, which may be extended to secondary & micro nutrients also (*Directorate of Soil Testing, Department of Agriculture, GoB*).
5. Trainings and awareness campaigns about the benefits of balanced use of fertilizers and ill effects of its excessive use in terms of costs and human hazards should be regularly arranged at village panchayat levels (*Directorate of Soil Testing, Department of Agriculture, GoB*).
6. Extension and scientific back-ups by the extension workers and KVK Scientists are essential for adoption of the recommended doses of fertilizers, which should be made available on priority basis (*Directorate of Soil Testing, Department of Agriculture, GoB*).
7. Demonstrations on the application of fertilizers for rabi, kharif and summer crops may be arranged for exposures to farmers with the view to make them familiar in regards to its uses (*Directorate of Soil Testing, Department of Agriculture, GoB*).
8. NPMSF should be in **mission mode**. Its augmentation will enrich the health of the soil and improve the economics of agricultural practices (*Ministry of Agriculture, Government of India*).