American Journal of Agricultural and Biological Sciences 3 (4): 716-723, 2008
ISSN 1557-4989


# Farmers' Use of Integrated Soil Fertility and Nutrient Management Practices for Sustainable Crop Production: A Field-level Study in Bangladesh

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**Abstract: Problem statement:** The most pressing problem for Bangladesh agriculture is the current state of gradual decreasing of soil fertility, stagnating crop yields and declining productivity in a range of food crops. According to crop production scientists, Integrated Soil Fertility (ISF) and Nutrient Management (NM) is an advanced approach that can serve as a remedy to improve crop yields and to preserve soil fertility in the long run. **Approach:** This study was therefore conducted to determine the extent of use ISF and NM practices by the farmers for their crop production in Bangladesh. Data were collected from 120 farmers (39 landless, 34 marginal, 19 small, 20 medium and 8 large farmers) from eight villages located in four districts in Bangladesh through face-to-face interviews from December 2005 to January 2006. **Results**: Most of the farmers were landless, marginal or small farm holders who rarely practiced soil fertility management means. Medium and large farmers did practice soil fertility management either occasionally or regularly. The use of organic manures by different categories of farmers indicated that medium and large farm holders were more careful about the use of cow dung, farmyard manure, crop residues, green manure and oil cakes as sources of organic manures than landless, marginal and small farm holders. Findings related to use of chemical fertilizers revealed that medium and large farmers often followed the recommended doses while landless, marginal and small farmers mostly applied chemical fertilizers based on their own assessment of soil conditions. **Conclusion/Recommendations:** Medium and large farmers are more prompt than landless, marginal and small farmers in terms of use of different components of ISF and NM practices for their crop production. The findings of this study might be helpful for the agricultural policy planners both from GOs and NGOs for developing effective crop production strategies considering soil fertility and plant nutrients aspects for landless, marginal and small farmers who constitutes about 74%of farming community in Bangladesh.

**Key words:** Use, management, integrated soil fertility, plant nutrient, sustainable crop production, farmers

## INTRODUCTION

The economy of Bangladesh is still dominated by agriculture, which supports the vast majority of its population. The country remains a food-deficit one, requiring on average 1 million tons of imported grain annually[4]. In the next 25 years, Bangladesh's food requirements are expected to increase by at least 70%. At the same time, it is not possible to expand the resource base of cultivated land. In fact, the amount of cultivated land is likely to shrink[9]. Therefore, Bangladesh will need a large boost in its ability to produce food for the teeming millions by using improved crop production technologies. Since there is little potential for the expansion of cultivated lands in Bangladesh, future agricultural productivity growth must come from integrated resource management approaches. Experiments have shown that integrated soil fertility and nutrient management practices increase soil and crop productivity as well as biological activity when compared to use of chemical fertilizers alone. Long-term trials of integrated soil fertility and nutrient management indicate that fertilizer input efficiency can be increased through: (i) management practices; (ii) the rational use of costly inputs; or (iii) the combination of both inputs and management practices. Adoption of some of these measures may not only enhance productivity but may increase the total productivity and the average efficiency of fertilizer use[6]. About 5.6 million ha of Bangladesh's land is deficient in

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phosphorus, 7.5 million ha are deficient in potassium and 8.7 million ha are deficient in sulfur for the production of upland crops[7]. Zinc deficiency has been identified in about 1.74 million ha of Bangladesh's land and boron deficiencies are now being noticed. The major cultivable crops of Bangladesh remove huge amount of nutrient elements from soil. High yielding varieties of rice, for example, uptake 108 kg $ha^{-1}$ N, 18 kg $ha^{-1}$ P, 120 kg $ha^{-1}$ K and 11 kg $ha^{-1}$ S from the soil. Wheat also removes large amounts of N and K from the soil. Present levels of crop production remove about 1.0 million tons of N, P, K and S from the soil annually[7]. Mismanagement of soil and plant nutrients by farmers further reduces the soil's nutrient reserves. As nutrient reserves are reduced, crop growth and productivity are compromised. Over time, cumulative nutrient depletion reduces agricultural production, crop yields and soil fertility, leading to soil degradation. Therefore, efficient and effective management of soil resources and plant nutrients is important for obtaining higher crop yields sustainably[9]. However, to date, little research has been conducted at the field level to measure the extent of different soil fertility management techniques or to measure the use of plant nutrients by farmers for sustainable crop production. Given this lack, this study was formulated at the field level to determine the extent of Integrated Soil Fertility (ISF) and Nutrient Management (NM) practices used by farmers for crop production.

## MATERIALS AND METHODS

**Research location, population and sampling:** Eight villages were selected for this research, two from each of the four districts in Bangladesh (Mymensingh, Jamalpur, Sherpur and Netrokona). These areas were selected due to: (i) the stagnation or reduction of crop yields in recent years[4] and ii) the gradual decline of soil fertility[7]. In addition, the average cropping intensity of the study area is 218%. This is higher than the national average for Bangladesh (181%). This indicates that farmers in the study areas cultivate their lands intensively (more than twice a year) to obtain more products to meet family needs. 598 farmers drawn from 494 families in the eight villages are the population of the study. About twenty percent of the total population (120 farmers: 39 landless, 34 marginal, 19 small, 20 medium and 8 large) were randomly sampled for the study.

**Measurement of farmers' use of ISF and nm practices:** Seven soil fertility management practices were selected for the study based on the recommendations of an expert panel from the Soil Science Department of Bangladesh Agricultural University. To measure the extent to which farmers use those techniques, a four-point summated rating scale was used. The respondents were asked to indicate the extent of their use of soil fertility management techniques as 'do not use', 'rarely use', 'occasionally use' or 'regularly use.' These responses were assigned scores of 0, 1, 2 and 3, respectively. Thus, a respondent could receive a score of 0 to 21 describing their overall use of different soil fertility management techniques. The Cronbach's alpha coefficient for this section was 0.89. Plant nutrient management, on the other hand, has two main aspects. These are the management of organic nutrients and the management of inorganic nutrients (chemical fertilizers). To collect data concerning farmers' use of organic manures for crop production, seven sources of manure were identified (cow dung, farm yard manure, crop residues, green manure, poultry feces, oil cake and ash) and the respondents were asked to describe the extent to which such manures were used. Possible responses were 'do not use', 'very low use' (1.0-3.0 ton $ha^{-1}$), 'low use' (3.1-5.0 ton $ha^{-1}$), 'moderate use' (5.1-7.0 ton $ha^{-1}$) and 'adequate use' (>7.0 ton $ha^{-1}$). These responses were assigned weights of 0, 1, 2, 3 and 4, respectively[7]. Thus, a farmer might receive a score of 0 to 28 describing the extent of that farmer's organic manure use in crop production. For this data, the Cronbach's alpha coefficient was 0.86. To measure the extent of farmers' use of chemical fertilizers, another four-point summated rating scale was employed. Seven types of chemical fertilizers were identified (Urea, Di-Ammonium Phosphate (DAP), SSP (Single Super Phosphate), Triple Super Phosphate (TSP), Muriate of Potash (MP), Gypsum and Zn fertilizers). The farmers were asked to indicate the extent to which each of these chemical fertilizers were used with: 'do not use', 'use a self-assessed dose', 'partial recommended dose' and 'recommended dose.' These responses were assigned a score of 0, 1, 2 and 3, respectively. Thus, a farmer could receive a score ranging from 0 to 21 describing the use of chemical fertilizers. The Cronbach's alpha coefficient for this section was 0.87. The Cronbach's alpha coefficients indicated that the measurement scales were internally consistent.

**Data collection and analysis:** Data were collected from the 120 sample farmers through face-to-face interviews using a structured survey questionnaire during the period from December 2005-January 2006. Information sought included farmers' use of soil fertility and nutrient management practices for crop production. Data were also collected from the Bangladesh Bureau of Statistics and reports on agriculture and rural development of the areas under study. The collected data was grouped, summarized and presented in tabular form. Descriptive statistics such as frequency distributions, percentages and mean and standard deviations were employed for data analysis.

## RESULTS

**Cropping patterns in the study area:** Cropping patterns are the arrangement of crops cultivated on a piece of land throughout the year[2] reported that cropping patterns have different effects on soil properties and thereby govern the soil conditions. Changes in the nutrient contents of different soils also occur due to the use of different fertilizers and the doses of such fertilizers applied to different cropping systems. This may modify the soil characteristics and nutrient contents. An individual farmer's requirements and interests may also influence the cropping patterns he follows. However, there are typically three agricultural seasons in Bangladesh: the summer season (March to June), the monsoon season (July to September) and a cold season (October to February).

The data shown in Table 1 demonstrate that the major cropping patterns in the study areas are Potato-Boro-T. aman (34% of the total cultivated land) and Boro-Fallow-T. aman (24% of total cultivated land), practiced by 37% and 23% of farmers, respectively. Another important cropping pattern is Boro-T. aman-Mustard, which covers 13% of the study area's cultivated land, with 12% of farmers practicing this pattern. Almost all of the cropping patterns are rice-centered and a negligible proportion of the farmers (8%) cultivate pulses.

**Yield gaps of major crops in the study area:** The data shown in Table 2 demonstrate that a wide gap exists between potential crop yields and the yields actually obtained by farmers in the study area. The average yield of improved rice, wheat, potato and mustard varieties in the study areas are far below the achievable yields of those crops. The yield of rice, potato, wheat, pulses and mustard may be increased significantly by using improved farm-management practices and an increase in crop production of more than 50 percent could be achieved by simply using high-yielding varieties of different crops along with the recommended doses of fertilizers and organic manures[7].

**Farmers' use of different soil fertility management practices:** The maintenance, enhancement and rehabilitation of soil fertility are important for food security. The data shown in Table 3 demonstrate that most farmers belong to resource-poor categories (landless, marginal and small farm holders) either do not practice or rarely practice soil fertility management techniques. The medium and large farmers, on the other hand, practice soil fertility management techniques more frequently than resource-poor farmers.

**Farmers' overall use of soil fertility management techniques:** The observed scores for the overall use of soil fertility management practiced by the interviewed farmers ranged from 0 to 18 (against a possible range of 0 to 21), with an average of 8.92 and a standard deviation of 1.53. The data shown in Table 4 show that a little more than three-fifths (61%) of the farmers use different soil fertility management techniques either rarely or occasionally, while 22% of them do not practice any type of soil fertility management. Only 17% of the total farmers practice soil fertility management techniques regularly.

Table 1: Existing cropping patterns, land allocation and farmers' practices in the study area

| Land type | Cropping patterns | Land Allocation (%) | Farmers practicing (%) |
|---|---|---|---|
| High land (not flooded) | Boro-Fallow-T. aman | 16 | 18 |
| | Potato-Boro-T. aman | 10 | 12 |
| | Pulses-Jute-Fallow | 5 | 4 |
| | Wheat-Fallow-T. aman | 5 | 5 |
| | Tomato-Aus-Vegetable | 3 | 3 |
| Sub-total | | 39 | 42 |
| Medium land (about half of the land is flooded) | Potato-Boro-T. aman | 24 | 25 |
| | Wheat-T. aman-Pulses | 5 | 5 |
| | Boro-T. aman-Mustard | 13 | 12 |
| | Tomato-Aus-Vegetable | 6 | 5 |
| Sub-total | | 48 | 47 |
| Low land (most of the land is flooded) | Boro-T. aman-Fallow | 8 | 5 |
| | Boro-Fallow-Fallow | 2 | 2 |
| | Jute-T. aman-Fallow | 3 | 4 |
| Sub-total | | 13 | 11 |
| Total | | 100 | 100 |

**Note:** T. aman indicates Transplant aman; Aus (March-June), Transplant aman (July-November), and Boro (December-April) are the three rice seasons in Bangladesh

Table 2: Yield gaps (m ton ha) of major crops in the study area

| Crops | 5 year (1999-2003) average yield (m ton ha$^{-1}$) | Average achievable (m ton ha$^{-1}$) yields with ideal management | Yield gap (m ton ha$^{-1}$) /(%) |
|---|---|---|---|
| **Rice** | | | |
| Aus | 1.63 | 2.91 | 1.28 (43%) |
| Aman | 2.13 | 3.70 | 1.57 (42%) |
| Boro | 2.60 | 4.55 | 1.95 (43%) |
| Wheat | 2.10 | 2.95 | 0.85(29%) |
| Potato | 9.85 | 22.90 | 13.05 (57%) |
| Mustard | 0.71 | 1.85 | 1.14 (62%) |
| Pulses | 0.92 | 1.98 | 1.06 (53%) |

Source: Researchers' own calculations from BBS, 2004

Table 3: Use of Integrated Soil Fertility (ISF) management techniques by the different categories of farmers

| Means of ISF management | Extent of use | Farmer categories<br>Landless (39) | Marginal (34) | Small (19) | Medium (20) | Large (8) |
|---|---|---|---|---|---|---|
| Practice of crop rotation | Do not | 11 (28) | 9 (26) | 4 (21) | 0 (0) | 0 (0) |
| | Rarely | 11(28) | 8 (24) | 2 (11) | 0 (0) | 0 (0) |
| | Occasionally | 14 (36 | 14 (41) | 7 (37) | 7 (35) | 2 (25) |
| | Regularly | 3 (8) | 3 (9) | 6 (31) | 13 (65) | 6 (75) |
| Legume cultivation | Do not | 26 (67) | 22 (64) | 10 (52) | 2 (10) | 0 (0) |
| | Rarely | 9 (23) | 8 (24) | 3 (16) | 3 (15) | 1 (13) |
| | Occasionally | 4 (10) | 3 (9) | 3 (16) | 5 (25) | 2 (26) |
| | Regularly | 0 (0) | 1 (3) | 3 (16) | 10 (50) | 5 (61) |
| Cultivation of green manuring crops | Do not | 32 (82) | 26 (76) | 13 (68) | 4 (20) | 1 (13) |
| | Rarely | 5 (13) | 4 (12) | 3 (16) | 3 (15) | 1 (13) |
| | Occasionally | 2 (5) | 4 (12) | 2 (11) | 7 (35) | 1 (13) |
| | Regularly | 0 (0) | 0 (0) | 1(5) | 6 (30) | 5 (61) |
| Practice of inter/mixed cropping | Do not | 24 (62) | 20 (59) | 4 (21) | 2 (10) | 0 (0) |
| | Rarely | 6 (15) | 7 (21) | 6 (32) | 3 (15) | 0 (0) |
| | Occasionally | 7 (18) | 4 (12) | 6 (32) | 7 (35) | 2 (25) |
| | Regularly | 2 (5) | 3 (8) | 3 (15) | 8 (40) | 6 (75) |
| Mulch application | Do not | 28 (72) | 19 (56) | 6 (32) | 2 (10) | 0 (0) |
| | Rarely | 7 (18) | 8 (24) | 4 (21) | 5 (25) | 1 (13) |
| | Occasionally | 3 (8) | 5 (15) | 5 (26) | 4 (20) | 2 (26) |
| | Regularly | 1 (2) | 2 (5) | 4 (21) | 9 (45) | 5 (61) |
| Dike Planting | Do not | 12 (31) | 10 (29) | 5 (26) | 0 (0) | 0 (0) |
| | Rarely | 10 (26) | 8 (24) | 3 (16) | 2 (10) | 0 (0) |
| | Occasionally | 13 (33) | 12 (35) | 6 (32) | 8 (40) | 2 (25) |
| | Regularly | 4 (10) | 4 (12) | 5 (26) | 10 (50) | 6 (75) |
| | Total | 39 (100) | 34 (100) | 19 (100) | 20 (100) | 8 (100) |
| Use of soil amendments | Do not | 33 (84) | 27 (80) | 13 (68) | 2 (10) | 1 (13) |
| | Rarely | 3 (8) | 5 (15) | 3 (16) | 3 (12) | 1 (13) |
| | Occasionally | 3 (8) | 2 (5) | 3 (16) | 5 (25) | 1 (13) |
| | Regularly | 0 (0) | 0 | 0 (0) | 10 (50) | 5 (61) |

**Note:** Figures in parenthesis indicate farmers' percentage; GM: Indicates 'green manure'

Table 4: Distribution of farmers according to their overall use of soil fertility management techniques

| Extent of use (score) | Farmers (120)<br>N | P | Possible range | Observed range | Mean | SD |
|---|---|---|---|---|---|---|
| Do not use (0) | 26 | 22 | 0-21 | 0-18 | 8.92 | 1.53 |
| Rarely use (1-7) | 32 | 26 | | | | |
| Occasional use (8-15) | 42 | 35 | | | | |
| Regularly use (>15) | 20 | 17 | | | | |

**Farmers' use of organic matter by source:** Table 5 shows a clear picture of the different sources of organic manures used by different categories of farmers. The data shown in Table 5 show that a big difference exists between the resource-poor (landless, marginal and small farm holders) and resource-rich farmers (medium and large farm holders) in the use of cow dung, farmyard manure, crop residues, green manure and oil cake as sources of organic manures. The use of poultry feces and ash as organic manures by the resource-poor farmers was also very low. Some organic manures can only be acquired (directly or indirectly) by cash payments, so resource-poor farmers typically use organic manures that do not require cash to acquire.

**Farmers' overall use of organic matter from different sources:** The observed score for the overall use of organic sources by farmers in the study area ranged from 0 to 24 (compared to a possible range of 0 to 28) with the average being 11.89. Based on the observed scores, the respondents were classified into five categories: 'do not use' (0), 'very low use' (1-7), 'low use' (8-14), 'moderately use' (15-20) and 'adequately use' (>20). The data shown in Table 6 indicate that one-half (50%) of the respondents use organic manures at either a very low or a low level. Of the remaining farmers, 25% reported moderate use of organic manures, with only 13% of farmers reporting that they use organic manures adequately. About one-seventh (14%) of the respondents do not use any type of organic manure for their crop production.

**Farmers' use of inorganic nutrients (chemical fertilizers) by type:** Chemical fertilizers are sources of inorganic nutrients and are a vital part of modern agriculture. The new high-yielding crop varieties which supply so much of the region's food only perform well when they are provided with a balanced and timely supply of plant nutrients. In most countries today, this need is mainly supplied by chemical fertilizers.

Table 5: Use of Organic Manures (OM) by different categories of farmers

| Sources of OM | Level of use | Farmer categories: Landless | Marginal | Small | Medium | Large |
|---|---|---|---|---|---|---|
| Cow dung | Do not | 14 (36) | 10 (29) | 3 (15) | 0 (0) | 0 (0) |
| | Very low | 12 (31) | 12 (35) | 7 (36) | 4 (20) | 0 (0) |
| | Low | 10 (26) | 8 (24) | 6 (31) | 3 (15) | 0 (0) |
| | Moderate | 3 (7) | 4 (12) | 2 (12) | 9 (45) | 2 (25) |
| | Adequate | 0 (0) | 0 (0) | 1 (6) | 4 (20) | 6 (75) |
| FYM | Do not | 12 (31) | 11 (32) | 2 (11) | 0 (0) | 0 () |
| | Very low | 13 (33) | 11 (32) | 5 (26) | 2 (10) | 0 (0) |
| | Low | 12 (31) | 7 (21) | 7 (37) | 5 (15) | 0 (0) |
| | Moderate | 2 (5) | 5 (15) | 4 (21) | 8 (40) | 1 (13) |
| | Adequate | 0 (0) | 0 (0) | 1 (5) | 5 (25) | 7 (87) |
| Crop residue | Do not | 30 (77) | 24 (70) | 10 (52) | 2 (10) | 0 |
| | Very low | 6 (15) | 3 (9) | 3 (16) | 3 (15) | 0 |
| | Low | 3 (8) | 7 (21) | 4 (21) | 3 (15) | 1 (13) |
| | Moderate | 0 (0) | 0 (0) | 2 (11) | 5 (25) | 2 (25) |
| | Adequate | 0 (8) | 0 (0) | 0 (0) | 7 (35) | 6 (72) |
| Green manure | Do not | 20 (51) | 16 (47) | 9 (47) | 2 (10) | 0(0) |
| | Very low | 14 (36) | 11 (32) | 5 (26) | 4 (20) | 0 () |
| | Low | 5 (13) | 6 (18) | 3 (16) | 6 (30) | 1(13) |
| | Moderate | 0 (0) | 1 (3) | 2 (11) | 3 (15) | 3 (38) |
| | Adequate | 0 (0) | 0 (0) | 0 (0) | 5 (25) | 4 (49) |
| Poultry feces | Do not | 5 (13) | 4 (12) | 2 (10) | 1 (5) | 0 (0) |
| | Very low | 9 (23) | 4 (12) | 2 (10) | 2 (10) | 0 (0) |
| | Low | 18 (46) | 19 (56) | 6 (32) | 5 (25) | 1 (13) |
| | Moderate | 5 (13) | 4 (12) | 6 (32) | 7 (35) | 2 (25) |
| | Adequate | 2 (5) | 3 (8) | 3 (16) | 5 (25) | 5 (32) |
| Oil cake | Do not | 16 (41) | 12 (35) | 6 (32) | 0 (0) | 0 (0) |
| | Very low | 14 (36) | 11 (32) | 2 (11) | 4 (20) | 0 (0) |
| | Low | 7 (18) | 6 (18) | 5 (26) | 5 (25) | 0 (0) |
| | Moderate | 2 (5) | 5(15) | 5 (26) | 6 (30) | 2 (25) |
| | Adequate | 0 (0) | 0 (0) | 1 (5) | 5 (25) | 6 (75) |
| Ash | Do not | 2 (5) | 1 (3) | 0 (0) | 0 (0) | 0 (0) |
| | Very low | 9 (23) | 8 (23) | 2 (11) | 0 (0) | 0 (0) |
| | Low | 21 (54) | 15 (44) | 3 (16) | 4 (20) | 0 (0) |
| | Moderate | 6 (15) | 8 (24) | 8 (42) | 6 (30) | 1 (13) |
| | Adequate | 1 (3) | 2 (6) | 6 (31) | 10 (50) | 7 (87) |

Figures in parenthesis indicate farmers' percentage; FYM indicates 'farm yard manure'

Table 6: Farmers' distribution based on their overall use of organic manures

| Level of use (score) | Farmers (120) F | P | Possible score | Observed score | Mean | SD |
|---|---|---|---|---|---|---|
| Do not use (0) | 14 | 12 | 0-28 | 0-24 | 11.89 | 1.78 |
| Very low use (1-7) | 24 | 20 | | | | |
| Low use (8-14) | 36 | 30 | | | | |
| Moderately use (15-20) | 30 | 25 | | | | |
| Adequately use (> 20) | 16 | 13 | | | | |

**Note:** 'f' and 'p' indicates frequencies and percentage of farmers respectively

The appropriate use of chemical fertilizers is essential for maintaining soil fertility and obtaining better yields. As agro-ecosystems are open and dynamic systems, balanced fertilization helps to supplement soil nutrient content to improve crop performance and minimize crop losses. Based on the typical cropping patterns found in the study areas, the recommended doses of Urea, DAP, SSP, TSP, MP, Gypsum and Zn fertilizers are 280, 230, 350, 128, 190, 45 and 5 kg $ha^{-1}$, respectively[7].

The data shown in Table 7 indicates that a major proportion of the landless, marginal and small farmers (resource-poor group) use chemical fertilizers based on their own assessment of the soil's needs with a lower proportion of farmers applying only part of the recommended fertilizer doses. The medium farmers try to apply chemical fertilizers according to the recommended doses while large farmers are more eager to apply different chemical fertilizers based on recommendations made by crop production specialists. Despite the fact that most cropping patterns in the study area require S and Zn, few farmers (particularly resource-poor farmers) apply fertilizers containing S and Zn. nutrients are provided in sufficient amounts and are readily available throughout crop growth.

Table 7: Use of chemical fertilizers by different categories of farmers

| | | Farmer categories | | | | |
|---|---|---|---|---|---|---|
| Type of Fertilizers | Level of use (dose) | Landless | Marginal | Small | Medium | Large |
| Urea (N containing) | Self-assessed | 31 (79) | 26 (76) | 10 (53) | 8 (40) | 1 (13) |
| | P. recom. | 8 (21) | 8 (24) | 8 (42) | 7 (35) | 2 (26) |
| | Recommended | 0 (0) | 0 | 1 (5) | 5 (25) | 5 (61) |
| DAP (N and P containing) | Self-assessed | 32 (82) | 27 (79) | 12 (63) | 10 (50) | 1 (13) |
| | P. recom. | 7 (18) | 7 (21) | 7 (37) | 6 (30) | 1 (13) |
| | Recommended | 0 (0) | 0 (0) | 0 | 4 (20) | 6 (74) |
| SSP (P containing) | Self-assessed | 34 (87) | 29 (85) | 14 (74) | 6 (30) | 1 (13) |
| | P. recom. | 5 (13) | 5 (15) | 5 (26) | 8 (40) | 3 (38) |
| | Recommended | 0 (0) | 0 (0) | 0 (0) | 6 (30) | 4 (49) |
| TSP (P containing) | Self-assessed | 33 (85) | 28 (82) | 13 (68) | 5 (25) | 0 (0) |
| | P. recom. | 6 (15) | 6 (18) | 6 (32) | 7 (35) | 2 (25) |
| | Recommended | 0 (0) | 0 (0) | 0 (0) | 8 (40) | 6 (75) |
| | Total | 39 (100) | 34 (100) | 19 (100) | 20 (100) | 8 (100) |
| MP (K containing) | Self-assessed | 31 (79) | 26 (76) | 10 (53) | 5 (25) | 0 (0) |
| | P. recom. | 8 (21) | 8 (24) | 9 (47) | 6 (30) | 1 (13) |
| | Recommended | 0 (0) | 0 (0) | 0 (0) | 9 (45) | 7 (87) |
| Gypsum (S containing) | Do not use | 23 (59) | 19 (56) | 10 (53) | 3 (15) | 1 (13) |
| | Self-assessed | 14 (36) | 13 (38) | 6 (32) | 7 (35) | 2 (25) |
| | P. recom. | 2 (5) | 2 (6) | 3 (15) | 10 (50) | 5 (62) |
| | Total | 39 (100) | 34 (100) | 19 (100) | 20 (100) | 8 (100) |
| $ZnO/ZnSO_4$ (Zn containing) | Do not use | 35 (90) | 28 (82) | 15 (78) | 6 (30) | 1 (13) |
| | Self-assessed | 4 (10) | 6 (18) | 4 (22) | 8 (40) | 3 (38) |
| | P. recom. | 0 (0) | 0 (0) | 0 (0) | 6 (30) | 4 (49) |

Figures in parenthesis indicate farmers' percentage; P. recom. indicates used part of the recommended application

Table 8: Farmers' distribution according to their response on overall use of chemical fertilizers

| Level of use (score) | Farmers (120) F | P | Possible score | Observed score | Mean | SD |
|---|---|---|---|---|---|---|
| Self assessed dose (1-6) | 57 | 48 | | | | |
| Partially recommended dose (7-12) | 47 | 39 | 0-21 | 1-18 | 9.28 | 1.57 |
| Recommended dose (13-18) | 16 | 13 | | | | |

Note: 'f' and 'p' indicate frequencies and percentage of farmers, respectively

**Overall use of inorganic nutrients (chemical fertilizers) by the farmers:** The possible score for the overall use of inorganic nutrients (chemical fertilizers) could range from 0-21, but the observed scores ranged from 1-18 with an average of 9.28. Overall, just under one-half (48%) of the farmers apply chemical fertilizers based on their own assessment of the soil's needs. About 39% of farmers use part of the recommended dose of fertilizers (Table 8). Only a negligible proportion of farmers (13%) use the recommended doses of fertilizers suggested by crop production specialists. A balanced dose of fertilizers (as recommended by crop production specialists) involves the deliberate application of all those nutrients that the soil cannot supply to meet the demands of growing crops[10].

## DISCUSSION

Although a few farmers cultivate green manure crops in their fields, there was no established cropping pattern found in the study area involving these crops. Rice-centered cropping patterns, along with an unwillingness to cultivate leguminous and green manure crops, create a nutritional imbalance and reduce the organic matter content of the soil. This not only diminishes crop yields, it also reduces soil fertility. Apart from improved varieties, agronomic measures to improve soil fertility and nutrient management can lead to dramatic yield improvement[8]. There are obvious deficiencies in the dissemination of technologies to the farmers, but the major problem is the chronic inability of most farmers to use such technologies properly. According to[1] the yield gap of different agricultural crops in Bangladesh may be minimized through the proper management of farms. The management of soil fertility and plant nutrients is an important tool of effective farm management for crop production[5].

Owing to frequent contact with government extension workers, greater access to information sources and ongoing soil fertility management projects, medium and large farmers acquired knowledge of soil fertility management techniques unavailable to resource-poor farmers. Poor soil fertility management leads to declining yields and undesirable environmental conditions. Due to the lack of adequate knowledge concerning soil fertility management and its importance to crop productivity, combined with poor access to information, irregular contact with extension programs and excessive population pressure, large segments of farmers in the study areas could not properly maintain soil fertility. Thus, the fertility of soils in the study areas is gradually declining with an obviously negative impact on crop yields.

It is well established that the frequency of application, nature and composition of organic materials affect the physical, chemical and biological properties of soil. Productive soil should be comprised of more than 3.5% organic matter. Currently most soils found in the study area (and Bangladesh as a whole) contain less than 1.3% organic matter. This is below the critical level and indicates alarmingly unsustainable crop production conditions. Agricultural production cannot be sustained if the nutrients removed during the cropping phase are not replenished and if appropriate agricultural practices are not implemented to maintain the soil's organic matter.

Due to a shortage of bio-fuel for cooking, the unavailability of organic matter and inadequate knowledge concerning the role of organic manure in soil fertility and crop productivity, farmers typically use most cow manure and farmyard wastes as bio-fuel. During the field survey, it was also observed that crop residues are widely used as bio-fuel and fodder and usually not returned to the soil. Combined with the intensive and continuous rice crops, organic matter in the soil and crop yields have both been reduced. Despite the fact that most cropping patterns in the study area require S and Zn, few farmers (particularly resource-poor farmers) apply fertilizers containing S and Zn. Due to a lack of financial resources and proper knowledge of balanced fertilization practices, the resource-poor farmers often use inappropriate fertilizers, leading to nutritional imbalances in the soil. Crop performance approaches its maximum yield potential when all essential nutrients are provided in sufficient amounts and are readily available throughout crop growth.

The aim of balanced fertilization is to correct any nutrient deficiency that may occur while a crop is being grown. Although chemical fertilizers are necessary to increase crop yields significantly, imbalanced use of chemical fertilizers creates problems[3] reported that the misuse of such fertilizers can reduce soil fertility and imbalance soil nutrients resulting in adverse environmental consequences and possible negative net returns arising from low crop yields. Chemical fertilizer is a purchase input and farmers' use of this input largely depends on their family income. The price of fertilizers and their availability during cropping seasons also influences farmers' use of chemical fertilizers. This study finds that the current use of chemical fertilizers by the farmers in the study area causes nutrient depletion and contributes to lower crop yields.

## CONCLUSION

Although crop yields is directly related to the maintenance of adequate soil fertility, organic matter and inorganic fertilizers, a significant proportion of farmers in the study area do not manage their farms properly. They focus on intense cultivation to meet food requirements rather than managing the nutrients in the soil. It is clear that the resource-poor groups (landless, marginal and small farmers) in the study area practice different techniques of soil fertility and nutrient management less frequently than medium and large farm holders. This is because agents of the on-going soil fertility management project mainly deal with farmers in the better-off categories. However, meeting the need for food, fiber and secure livelihoods in Bangladesh will require the conservation of soil and plant nutrient resources. Therefore, it is essential that the government and non-governmental extension organizations in Bangladesh should take measure to help farmers, especially the resource-poor group to increase their knowledge about Integrated Soil Fertility (ISF) and Nutrient Management (NM) approach and its components so that they can practice these properly to increase their crop yields and maintain soil fertility not only for present generation but for future generations also.

## ACKNOWLEDGEMENT

The researchers are grateful to the farmers of the study area for their kind cooperation and all out Support during data collection.

## REFERENCES

1. Ahmed, A. and R. Shibasaki, 2000. Climate change and agricultural food production of bangladesh: An impact assessment using gis-based biological crop simulation model. http://www.gisdevelopment.net/aars/acrs/2000/ts1/agri004a.asp.
2. Anderson, I.C., D.R. Buxton, D.L. karlen and C. Camberdella, 1997. Cropping systems affects on nitrogen removal, soil nitrogen, aggregate stability and subsequent crop grain yield. Agron. J., 89: 881-886. http://agron.scijournals.org/cgi/content/abstract/89/6/881.

3. Awe, O.A., 1997. Soil fertility management using organic fertilizers and low-external-input techniques. Proceeding of the National Workshop on Soil Conservation and Soil Fertility Management for Sustainable Rural Development, Nov. 5-7, Owerri, Imo State, Nigeria.
4. BBS., 1986. Statistical year book of Bangladesh. http://www.popline.org/docs/0781/227111.html.
5. FAO., 1998. Guide to efficient plant nutrition management. ftp://ftp.fao.org/agl/agll/docs/gepnm.pdf.
6. Gupta, R.K., 1996. Nutrient management in rice-wheat systems for sustainability for soil resource base. Proceeding of the Conference on New Frontiers of Research in Indian Agriculture, Jan. 2-4, ICAR Publications, New Delhi, India, pp: 158-171.
7. Hasan, M.K. and A.K.M.A. Alam, 2006. Land degradation situation in bangladesh and role of agroforestry. J. Agric. Rural Develop., 4: 19-25. http://www.banglajol.info/index.php/JARD/article/viewPDFInterstitial/763/801.
8. IAC., 2004. Realizing the promise and potential of african agriculture. http://www.ifpri.org/events/seminars/2004/20041206.htm.
9. IFPRI., 2001. Sustainable food security for all by 2020. Nutr. Bull., 26: 351-352. DOI: 10.1046/j.1467-3010.2001.00188.x.
10. Tandon, H.L.S., 1992. Assessment of soil nutrient depletion. Proceedings of the Regional FADINAP Seminar on Fertilization and the Environment, Sep. 7-11, Chiang Mai, Thailand, pp: 203-219.