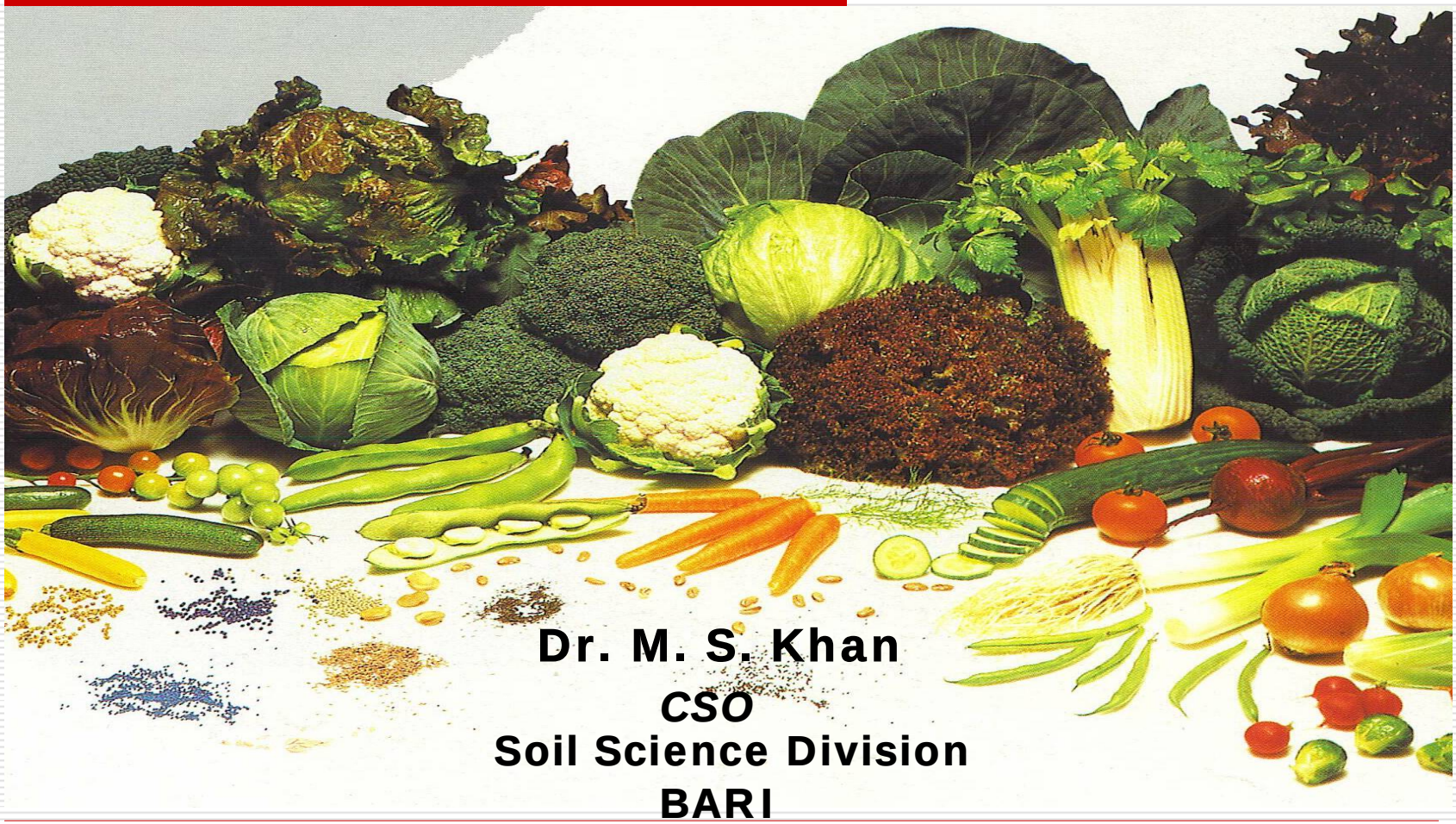
# *Welcome*

# Integrated nutrient management for sustainable yield of major vegetable crops in Bangladesh



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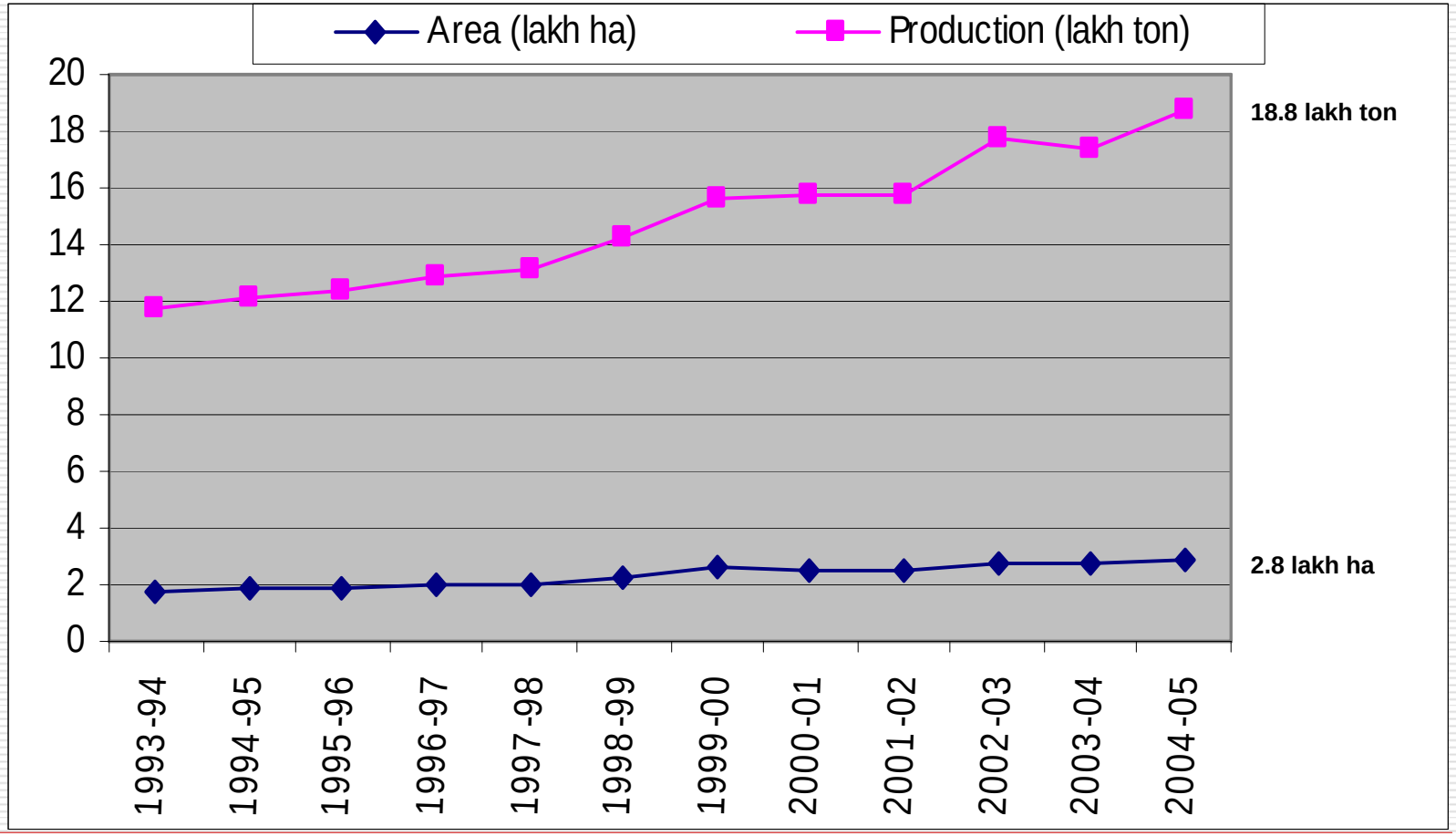
# Vegetable Production & Consumption in Bangladesh

| | |
|---|---|
| Area | 197508 ha |
| Production | 1.371 million tons |
| Present consumption | 120g/day/person **(AVRDC, 2000)** |
| Recommendation | 220g/day/person |
| Requirement (as per recommendation) | 11.24 million MT |
| Production to be increased (as per recommendation) | 6 folds of the present production |

**Source: AVRDC, 2000**

# Production Trend



- **Increasing cropping intensity to meet the demands for food for a swelling population has led to mining out the inherent plant nutrients from the crop fields, thereby fertility status of soils severely declined in Bangladesh over the years.**

- **Because of cumulative negative nutrient balance the farming system has become unsustainable.**

Puddling Causes
Plough Pan Formation

Removal of silt/sand
from crop land

Application of organic matter

Removal of crop residues

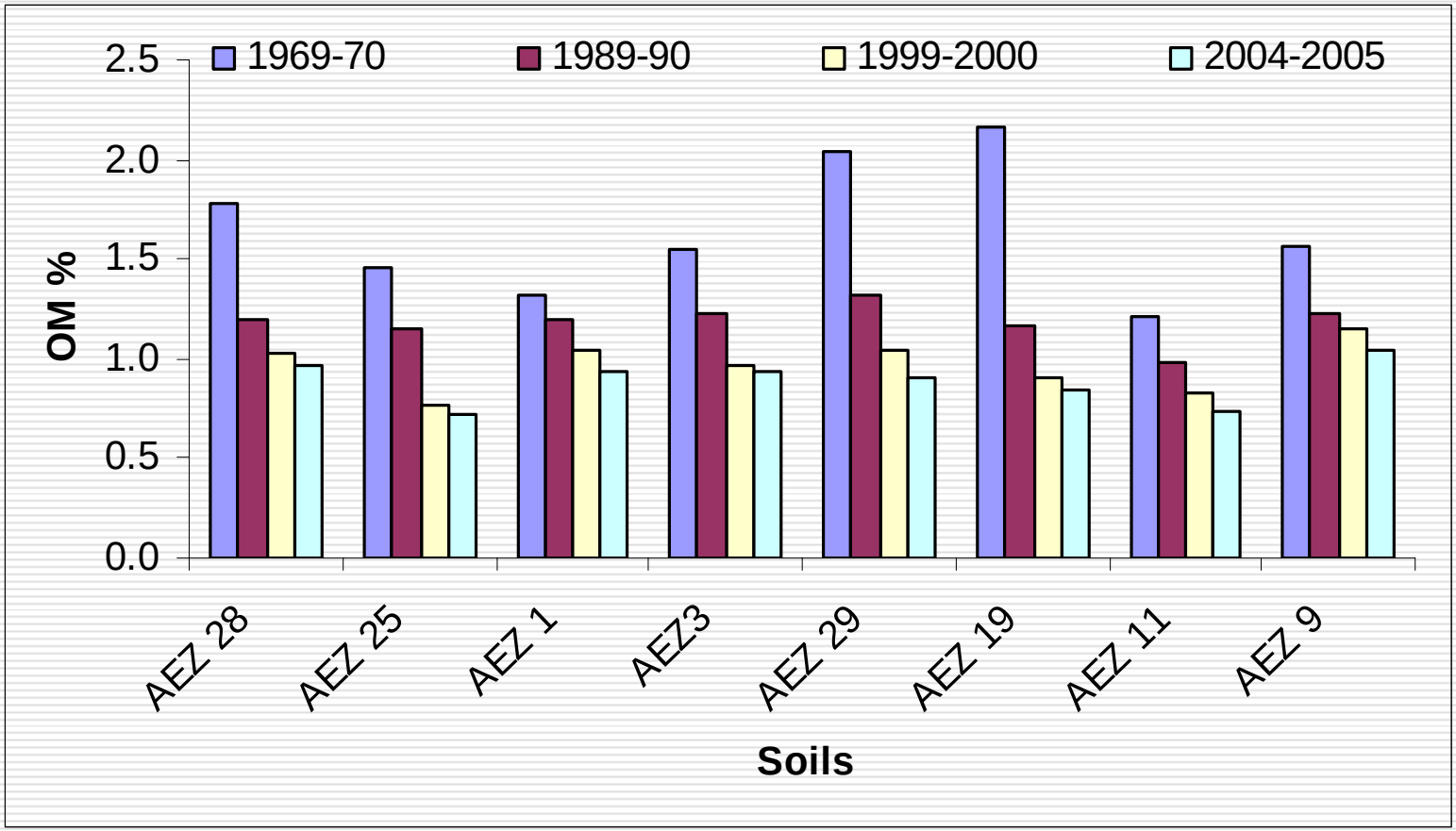
# Problems of Chittagong Hill Tracts

- Shifting cultivation
- Deforestation
- Soil erosion
- Soil fertility degradation
- Environment degradation

- **The total fertilizer used in the country, urea alone constitutes about 80% (BARC, 2005).**

- **Organic matter content in Bangladesh soils is very low, the majority being below the critical level (1.5%), and it gradually depleted by 5 to 36% during the period of 1967-1995 (Ali *et al*., 1997).**

# Depletion of soil organic matter in different Agro-Ecological Zones of Bangladesh



- **Since the nutrient turnover in soil plant system is considerably high in intensive vegetables cultivation, neither the chemical fertilizers nor the organic manure alone can help to achieve sustainable production.**

# Integrated nutrient management approach since 1990 in BARI

## Integration of organic, inorganic & green manuring for sustainable agriculture


- **Considering the above perspectives, Soil Science Division of BARI conducted numerous experiments with vegetable crops:**

  **Tomato**
  **Cabbage**
  **Cauliflower**
  **Broccoli**
  **Pea**
  **Sweet pepper and**
  **Potato**

# Objective:

**The aim of the present paper is to provide some of the key findings of research as conducted by Soil Science Division of BARI during the recent years.**

# Materials and Methods

**The present paper is entirely a review paper. It is written as adapting and citing some notable research findings of Soil Science Division, BARI, conducted during recent years (2000-2007).**

# Results and Discussion

## Table 1. Yield of tomato as influenced by organic manure (OM) and chemical fertilizer (CF)

| Treatment | Chemical fertilizer | PM | CD | Yield (t ha$^{-1}$) | | | Yield increase (%) |
|---|---|---|---|---|---|---|---|
| | | t ha$^{-1}$ | | 2002-03 | 2003-04 | 2004-05 | |
| $T_1$ | 100% RD* | 2.5 | 0 | 75.0a | 70.8a | 69.6a | 282 |
| $T_2$ | 100% RD | 0 | 2.5 | 66.1bc | 64.5bc | 61.7bc | 241 |
| $T_3$ | 100% RD | 0 | 0 | 64.8bc | 63.1bc | 60.7bc | 234 |
| $T_4$ | 50% RD | 0 | 0 | 48.1d | 46.6de | 48.7de | 154 |
| $T_5$ | 50% RD | 5 | 0 | 68.1ab | 65.4ab | 66.1ab | 254 |
| $T_6$ | 50% RD | 10 | 0 | 70.8ab | 67.2ab | 66.5ab | 263 |
| $T_7$ | 50% RD | 0 | 10 | 60.3c | 61.0c | 59.4c | 220 |
| $T_8$ | 25% RD | 10 | 0 | 52.1d | 50.5d | 52.6d | 175 |
| $T_9$ | 25% RD | 0 | 10 | 45.4de | 42.5ef | 48.0de | 141 |
| $T_{10}$ | 0 | 10 | 0 | 40.7e | 39.5f | 38.8f | 111 |
| $T_{11}$ | 0 | 10 | 10 | 28.8f | 25.0g | 24.0g | 38 |
| $T_{12}$ | Absolute control | | | 19.9g | 19.1h | 17.4h | - |
| CV (%) | | | | 7.3 | 5.90 | 6.10 | - |

*RD (Recommended dose of chemical fertilizer, kg ha$^{-1}$) = $N_{150}P_{45}K_{80}S_25Zn_2B_1$

CD = cow dung and PM = poultry manure

# Table 2. Curd yield of broccoli as influenced by integrated use of OM and CF at Joydebpur, Gazipur

| Treatment | Chemical fertilizer | PM | CD | Yield (t ha$^{-1}$) | | Yield increase (%) |
|---|---|---|---|---|---|---|
| | | t ha$^{-1}$ | | 2002-03 | 2003-04 | |
| $T_1$ | 100% RD* | 2.5 | 0 | 25.34a | 23.5a | 510 |
| $T_2$ | 100% RD | 0 | 2.5 | 21.5cd | 19.9bc | 417 |
| $T_3$ | 100% RD | 0 | 0 | 20.0d | 18.3cd | 379 |
| $T_4$ | 50% RD | 0 | 0 | 10.58f | 10.9ef | 169 |
| $T_5$ | 50% RD | 5 | 0 | 22.6bc | 20.7bc | 442 |
| $T_6$ | 50% RD | 10 | 0 | 24.4ab | 22.2ab | 482 |
| $T_7$ | 50% RD | 0 | 10 | 19.3d | 17.2d | 355 |
| $T_8$ | 25% RD | 10 | 0 | 14.6e | 13.0e | 245 |
| $T_9$ | 25% RD | 0 | 10 | 9.4fg | 10.1f | 144 |
| $T_{10}$ | 0 | 10 | 0 | 9.16fg | 9.54fg | 133 |
| $T_{11}$ | 0 | 10 | 10 | 7.42g | 7.61g | 88 |
| $T_{12}$ | Absolute control | | | 3.80h | 4.20h | - |
| CV (%) | | | | 8.6 | 9.2 | |

*RD (kg ha$^{-1}$) = $N_{140}$ $P_{45}$ $K_{80}$ $S_{25}Zn_2B_1Mo_{0.5}$

CD = cow dung and PM = poultry manure

# Table 3. Effect of N fertilizer use together with residual effect of OM and CFs* on the yield and yield contributing characters of okra at Joydebpur, Gazipur

| Treatment | N fertilizer | No. of fruits plant$^{-1}$ | | Fruit yield (t/ha) | | Yield increase (%) |
|---|---|---|---|---|---|---|
| | | 2002-03 | 2003-04 | 2002-03 | 2003-04 | |
| $T_1$ | 100% RD** | 34.8a | 29.3a | 13.72a | 10.88a | 611 |
| $T_2$ | 100% RD | 28.6bc | 23.3bc | 11.26bc | 8.48bc | 470 |
| $T_3$ | 100% RD | 27.3bc | 22.0c | 10.48bc | 7.86bc | 430 |
| $T_4$ | 50% RD | 17.3d | 15.0d | 4.55e | 4.72de | 168 |
| $T_5$ | 50% RD | 30.2b | 24.8b | 11.78b | 8.86b | 496 |
| $T_6$ | 50% RD | 33.6a | 27.9a | 13.34a | 10.24a | 580 |
| $T_7$ | 50% RD | 26.1c | 21.6c | 10.00c | 7.46c | 405 |
| $T_8$ | 25% RD | 19.8d | 16.8d | 7.56d | 5.66d | 282 |
| $T_9$ | 25% RD | 13.5e | 11.3e | 4.30e | 4.58f | 157 |
| $T_{10}$ | 0 | 17.0d | 14.2d | 3.90e | 3.38ef | 110 |
| $T_{11}$ | 0 | 11.5e | 9.2e | 3.52e | 2.98f | 88 |
| $T_{12}$ | Absolute control | 7.4f | 5.1f | 1.86f | 1.60g | - |
| CV (%) | | 7.4 | 5.1 | 9.8 | 10.8 | |

* Residue of broccoli treatment with organic manures and chemical fertilizers

**RD (kg $ha_{-1}$) = $N_{150}$

# Table 4. Yield of cabbage as influenced by integrated use of organic manure and chemical fertilizer at Joydebpur during 2001-02 and 2002-03

| Treatment | Chemical fertilizer | CD | PM | OC | Head yield (t ha$^{-1}$) | | | Yield increase (%) |
|---|---|---|---|---|---|---|---|---|
| | | t ha$^{-1}$ | | | 2000-01 | 2001-02 | Mean | |
| $T_1$ | 100% RD* | 0 | 0 | 0 | 67.36b | 61.82cd | 64.59 | 208 |
| $T_2$ | 70% RD | 0 | 0 | 0 | 52.86d | 45.24e | 49.05 | 134 |
| $T_3$ | 70% RD | 5 | 0 | 0 | 60.44c | 57.22d | 58.83 | 181 |
| $T_4$ | 70% RD | 10 | 0 | 0 | 70.76b | 65.56c | 68.16 | 225 |
| $T_5$ | 70% RD | 0 | 5 | 0 | 73.32b | 74.86b | 74.09 | 253 |
| $T_6$ | 70% RD | 0 | 10 | 0 | 81.28a | 81.80ab | 81.54 | 289 |
| $T_7$ | 70% RD | 0 | 0 | 2.5 | 84.88a | 84.62a | 84.75 | 304 |
| $T_8$ | 70% RD | 0 | 0 | 5 | 87.25a | 86.94a | 87.10 | 316 |
| $T_9$ | Absolute control | | | | 22.14e | 19.78f | 20.96 | - |
| CV (%) | | | | | 5.6 | 6.4 | - | - |

*RD (kg ha$^{-1}$) = $N_{250}P_{36}K_{80}S_{40}B_2Mo_1$

## Table 5. Effect of potassium and irrigation on the yield of carrot at Joydebpur, Gazipur

| Treatment | Irrigation level | K dose (kg ha$^{-1}$) | Mean yield (t ha$^{-1}$) | Yield increase (%) |
|---|---|---|---|---|
| $T_1$ | $I_0$ (No Irrigation) | 0 | 8.4 | - |
| $T_2$ | | 75 | 9.2 | 9.3 |
| $T_3$ | | 100 | 9.2 | 9.3 |
| $T_4$ | | 125 | 9.6 | 14.3 |
| $T_5$ | $I_1$ (One Irrigation at 20 DAS) | 0 | 8.9 | 6.0 |
| $T_6$ | | 75 | 9.5 | 13.1 |
| $T_7$ | | 100 | 13.6 | 61.9 |
| $T_8$ | | 125 | 16.0 | 90.5 |
| $T_9$ | $I_2$ (One Irrigation at 40 DAS) | 0 | 9.3 | 10.7 |
| $T_{10}$ | | 75 | 14.4 | 71.4 |
| $T_{11}$ | | 100 | 16.1 | 91.7 |
| $T_{12}$ | | 125 | 18.5 | 120.2 |
| $T_{13}$ | $I_3$ (Two Irrigation at 20 & 40 DAS) | 0 | 10.1 | 20.2 |
| $T_{14}$ | | 75 | 16.6 | 97.6 |
| $T_{15}$ | | 100 | 19.6 | 133.3 |
| $T_{16}$ | | 125 | 20.0 | 138.1 |

***Note:*** Blanket dose of $N_{120}P_{40}S_{20}$ (kg ha$^{-1}$) + cow dung at 5 t ha$^{-1}$

# Table 6. Effect of integrated use of chemical fertilizers and organic manure on radish and tomato under radish-tomato-red amaranth-Indian spinach cropping pattern at Joydebpur during 2000-01 and 2001-02

| Treat. | Yield (t ha$^{-1}$) | | | | | | | | Tomato Equivalent yield (t ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| | Treat. | Chemical fertilizer | Radish & tomato | | Red amaranth & Indian spinach | | | | |
| | Radish | Tomato | Red amaranth | | Indian spinach | | | | |
| | 2000-01 | 2001-02 | 2000-01 | 2001-02 | 2000-01 | 2001-02 | 2000-01 | 2001-02 | |
| $T_1$ | 41.84b | 41.12b | 65.51b | 68.00bc | 11.35cd | 11.54c | 26.58d | 27.16bc | 78.70 |
| $T_2$ | 33.24d | 33.57d | 54.26cd | 56.90c | 8.50ef | 9.12e | 21.34ef | 21.85cd | 88.11 |
| $T_3$ | 40.12bc | 40.70b | 61.98bc | 64.66bc | 11.87c | 12.16c | 27.05cd | 27.44bc | 87.01 |
| $T_4$ | 45.37b | 45.87b | 68.58b | 71.70b | 14.17b | 14.44b | 31.69bc | 33.05b | 122.22 |
| $T_5$ | 59.32a | 63.25a | 89.87a | 90.57a | 15.97a | 16.18a | 47.36a | 48.04a | 162.59 |
| $T_6$ | 61.35a | 63.58a | 92.12a | 93.32a | 16.87a | 17.22a | 47.74a | 48.62a | 166.37 |
| $T_7$ | 25.22e | 26.28e | 43.99d | 46.25d | 7.00f | 7.48f | 17.46f | 18.00d | 50.45 |
| $T_8$ | 35.50cd | 37.17cd | 54.00cd | 57.64c | 9.56de | 10.00de | 23.92de | 25.00d | 58.20 |
| $T_9$ | 40.00bc | 40.28bc | 59.21bc | 61.83bc | 10.92cd | 11.28cd | 32.16b | 33.64b | 109.14 |
| $T_{10}$ | 9.73f | 10.65f | 27.21e | 26.37e | 3.12g | 3.28g | 9.38g | 10.42e | 35.09 |
| CV (%) | 7.8 | 7.2 | 9.6 | 9.3 | 9.4 | 6.7 | 4.8 | 7.8 | - |

| | |
|---|---|
| $T_1$ | 100% RD |
| $T_2$ | 75% RD |
| $T_3$ | 75% RD |
| $T_4$ | 75% RD |
| $T_5$ | 75% RD |
| $T_6$ | 75% RD |
| $T_7$ | 50% RD |
| $T_8$ | 50% RD |
| $T_9$ | 50% RD |
| $T_{10}$ | Control |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PM | CD | PM | CD | PM | CD | PM | CD | t ha$^{-1}$ |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 0 | 5 | 0 | 2.5 | 0 | 5.0 | 0 | 5.0 | |
| 0 | 10 | 0 | 5 | 0 | 10 | 0 | 10 | |
| 0 | 0 | 2.5 | 0 | 5.0 | 0 | 5.0 | 0 | |
| 0 | 0 | 5 | 0 | 10 | 0 | 10 | 0 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 0 | 10 | 0 | 5 | 0 | 10 | 0 | 10 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

*RD (kg ha$^{-1}$) = $N_{150}P_{35}K_{80}S_{10}$ for radish; $N_{150}P_{45}K_{80}S_{20}B_1$ for tomato; $N_{60}$ for red amaranth; $N_{100}$ for Indian spinach

## Table 7. Yield of vegetables in tomato-okra-Indian spinach cropping pattern as influenced by integrated use of chemical fertilizers and organic manure at homestead of Elenga, Tangail, during 2005-06

| Tr. | Chemical fertilizer | Tomato | | Okra | | Indian spinach | | Yield (t ha$^{-1}$) | | | Tomato equivalent yield (t ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PM | CD | PM | CD | PM | CD | Tomato | Okra | Indian spinach | |
| | | t ha$^{-1}$ | | | | | | | | | |
| $T_1$ | 100%RD* | 0 | 0 | 0 | 0 | 0 | 0 | 64.2ab | 9.7ab | 36.2a | 102.7 |
| $T_2$ | 75% RD | 10 | 0 | 5 | 0 | 0 | 0 | 66.4a | 20.8a | 34.7ab | 104.5 |
| $T_3$ | 75% RD | 0 | 10 | 0 | 5 | 0 | 0 | 60.2b | 18.8abc | 32.5abc | 95.76 |
| $T_4$ | 50% RD | 10 | 0 | 10 | 0 | 0 | 0 | 58.7b | 17.3bcd | 30.8bc | 91.78 |
| $T_5$ | 50% RD | 0 | 10 | 0 | 10 | 0 | 0 | 53.3c | 15.4cd | 28.4c | 73.1 |
| CV (%) | | | | | | | | 6.5 | 9.8 | 7.3 | |

*RD (kg ha$^{-1}$) = $N^{150}P^{40}K^{80}S^{20}Zn^{2}B^{1}$ for tomato; $N_{120}P_{35}K_{70}S_{15}Zn_2B_1$ for okra and $N_{120}$ for Indian spinach

## Table 8. Yield of cabbage and tomato as influenced by nutrient management and plant population under intercropping system at Jessore during 2005-06 and 2006-07

| Treatment | Head yield of main crop (cabbage) | | Fruit yield of intercrop (tomato) | |
|---|---|---|---|---|
| | 2005-06 | 2006-07 | 2005-06 | 2006-07 |
| | t $ha^{-1}$ | | | |
| **Plant population (PP)** | | | | |
| $PP_1$ (100% main crop + 20% intercrop) | 44.50 | 42.26 | 6.60b | 7.43b |
| $PP_2$ (100% main crop + 30% intercrop) | 42.88 | 40.34 | 7.41a | 8.43a |
| Significance level | NS | NS | * | ** |
| **Nutrient management (NM)** | | | | |
| $NM_1$ (crop removal based dose) | 55.97a | 51.87ab | 8.07kb | 8.98b |
| $NM_2$ (FRG 2005 based dose) | 57.77a | 54.45a | 9.99a | 11.75a |
| $NM_3$ (IPNS based dose) | 50.02b | 49.47b | 7.81b | 8.57b |
| $NM_4$ (control) | 10.99c | 11.42c | 2.14c | 2.43c |
| Significance level | * | * | * | ** |
| CV (%) | 9.7 | 10.3 | 11.5 | 12.5 |

*P < 0.05; **P < 0.01

# Nutrient balance

**An apparent nutrient balance was estimated on the basis of nutrient added to the soil and the amount of nutrient uptake by the crops in cabbage with tomato intercropping system.**

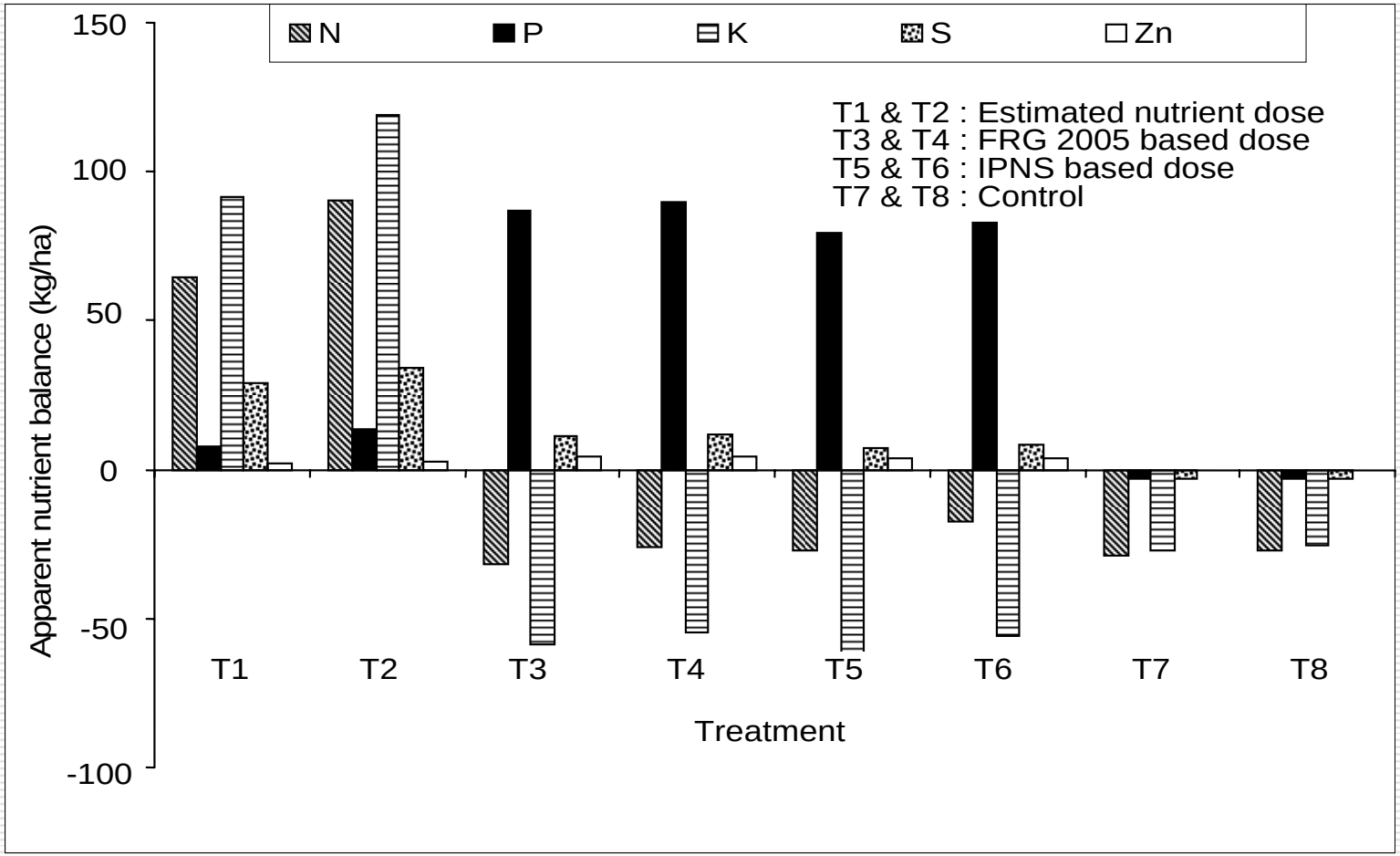
**The study revealed that all the nutrients showed positive balances in the $NM_1$ treatment (crop removal based dose) that might be due to the lower yield than the target, caused by short span winter.**

**Phosphorus balance was highly positive in the $NM_2$ package (FRG'05 based dose) and also in $NM_3$ (IPNS based dose) while N and K balances were negative.**

**The higher amount of P addition compared to the uptake (requirement) coupled with the lower yield might be the main reasons for P build-up in $NM_1$ & $NM_3$ packages.**

**However, S and Zn balances were positive for all the treatments except control (Shil *et al.*, 2007).**

**Fig. 1. Apparent nutrient balances for different treatments under cabbage with tomato intercropping system at RARS, Jessore during 2005-06**



# Soil fertility status

**Studies regarding the post-harvest soil fertility status after the cultivation of vegetable crops were not done widely so far. However, the fertility status of post-harvest soil after the cultivation of tomato under integrated nutrient management approach revealed (Noor *et al*., 2006) that the content of organic matter slightly improved (by 18%) when higher rate of poultry manure was applied.**

## Table 9. Pre- and post-harvest soil fertility status of tomato plots grown under integrated nutrient management approach at Central Farm, BARI, Joydebpur, during 2004-05

| Treatment | pH | OM (%) | Total N (%) | K (meq/100 g) | P | S | Zn | B |
|---|---|---|---|---|---|---|---|---|
| | | | | | ppm | | | |
| **Initial** | | | | | | | | |
| | 6.1 | 1.9 | 0.09 | 0.21 | 12 | 10 | 1.5 | 0.35 |
| **Post-harvest** | | | | | | | | |
| $T_1$ | 6.2 | 1.9 | 0.10 | 0.18 | 22 | 13 | 1.8 | 0.35 |
| $T_2$ | 6.2 | 2.2 | 0.08 | 0.17 | 21 | 12 | 1.7 | 0.32 |
| $T_3$ | 6.3 | 1.8 | 0.08 | 0.15 | 20 | 12 | 1.6 | 0.30 |
| $T_4$ | 6.1 | 1.7 | 0.07 | 0.14 | 19 | 11 | 1.6 | 0.28 |
| $T_5$ | 6.0 | 1.9 | 0.09 | 0.14 | 18 | 12 | 1.7 | 0.29 |
| $T_6$ | 6.1 | 2.1 | 0.11 | 0.16 | 20 | 13 | 1.9 | 0.34 |
| $T_7$ | 6.2 | 1.8 | 0.09 | 0.14 | 17 | 11 | 1.7 | 0.25 |
| $T_8$ | 6.1 | 1.9 | 0.10 | 0.13 | 14 | 11 | 1.7 | 0.22 |
| $T_9$ | 6.0 | 1.7 | 0.07 | 0.13 | 14 | 10 | 1.6 | 0.23 |
| $T_{10}$ | 5.9 | 1.8 | 0.08 | 0.12 | 16 | 12 | 1.7 | 0.24 |
| $T_{11}$ | 6.1 | 1.7 | 0.07 | 0.10 | 14 | 10 | 1.5 | 0.20 |
| $T_{12}$ | 6.0 | 1.7 | 0.06 | 0.09 | 13 | 10 | 1.3 | 0.18 |
| Critical level | - | - | 0.12 | 0.20 | 14 | 14 | 2.0 | 0.20 |

# Cost and return

**Economic analysis revealed that higher dose of organic manure along with chemical fertilizer gave lower marginal rate of return (MRR) due to higher cost involvement (cost dominated) even if its gross margin was higher.**

**However, moderate dose of organic manure along with chemical fertilizer appeared as cost un-dominated showing higher MRR as well as economic benefit in most cases.**

**Considering the gross margin, economic benefit (MRR), quality (shape, size and appearance) and quantity (yield) of the product, cost and availability of manures, soil fertility regeneration, the moderate dose of poultry manure (5 t $ha^{-1}$) along with 50-75% chemical fertilizer from the present recommendation may be regarded as the best suited combination for the cultivation of major vegetable crops.**

# Conclusions

- Yield of different vegetables increased substantially due to integrated use of both organic manure and chemical fertilizers.
- Poultry manure appeared as the best source of organic manure over cow dung.
- Integrated use of both chemical fertilizer and poultry manure may reduce the use of chemical fertilizer from the present conventional recommendation.
- Further depletion of soil fertility may be checked with positive trend of improvement.
- Moderate dose of poultry manure along with chemical fertilizer appeared as cost un-dominated providing higher marginal rate of return.

# Recommendations

**Moderate dose of poultry manure (5 t $ha^{-1}$) along with 50-75% recommended dose of chemical fertilizer for the respective crop may be recommended for the major vegetable crops and their patterns for yield sustainability and improvement of soil fertility in Bangladesh.**

# Future research suggested

**Further research should be undertaken on location specific (agro-ecological zone based) appropriate INM system for different crops and cropping patterns through integrating chemical fertilizers and all possible sources of organic manures depending on their availability and considering their environmental, agronomical and economical perspectives as well as possibilities.**

## Tomato

BARI Tomato-3

## Broccoli

## Homestead vegetable

## Cabbage

## BARI Fulcopi- 2

## BARI Bandha Kopi-1 (Provati)

## BARI Dherosh-1


## BARI Barboti -1

## BARI Begun-8

## BARI Mula-1 (Tasaki mula)

## BARI Hybrid Begun-2 (Tarapuri)

## BARI Begun-4 (Kazla)

## BARI Potol-2

## BARI Seem-1

## BARI Motor Shuti-1

## BARI Jhar Seem-1 (French bean)

## BARI Lau-2

## BARI Karola-1

*Thanks*