



Effects of Integrated Nutrient Management on the Performance of Mango on Hills in Three Districts, Bangladesh

Md. Zonayet^{1*}, Alok Kumar Paul² and Mostak Ahmed³

¹Krishi Gobeshona Foundation (KGF), CRP-1: Hill Agriculture, Sustainable Land Management (Component-II), Bandarban, Bangladesh.

²Department of Soil Science, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh.

³On-Farm Research Division (OFRD), Bangladesh Agricultural Research Institute, Bandarban, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. Author MZ designed the study, performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript and managed the analyses of the study. Authors AKP and MA managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI:10.9734/AJSSPN/2020/v6i330088

Editor(s):

(1) Dr. Pankaj Kumar, H. N. B. Garhwal Central University, India.

Reviewers:

(1) Sri Harini, University Malang, Indonesia.

(2) Samuel Ayesu, Forestry Commission, Ghana.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/57721>

Original Research Article

Received 17 April 2020

Accepted 22 June 2020

Published 02 July 2020

ABSTRACT

This experiment was conducted in a mango garden at Bandarban, Khagrachari and Rangamati district in hilly area of Bangladesh from 15 October 2015 to 30 May 2017 to study the effects of integrated nutrient management on the performance of mango in hills. The experiment was laid out in a randomized block design with three replications. There were four treatments Mango (5-10 yrs. old). The treatments are: 4 (four) Fertilizer packages * T₁= Control, T₂= N₂₃₀P₅₃K₁₀₀ S₃₆Zn₃ B₄ + CD/Compost 20000 g/plant, T₃= 125% of T₂ and T₄= 150% of T₂. In Khagrachari site, Mango yield varied from 7.72-22.30 kg/plant. The highest mango yield 22.30 kg/plant was in T₄ treatment (150% of T₂). In Bandarban site, Mango yield ranged between 24.13-48.25 kg/plant. The highest mango yield 48.25 kg/plant found in T₃ treatment (125% of T₂). In Rangamati site, Mango yield varied from 9.62-23.10 kg/plant. The highest mango yield 23.10 kg/plant found in T₄ treatment (150% of T₂). In most cases the significant difference in yields were found in T₄ treatments in three districts.

*Corresponding author: Email: zonayetamin@gmail.com;

Keywords: INM; soil fertility; yield of mango.

1. INTRODUCTION

Mango (*Mangifera indica*) is the favorite fruit in Bangladesh and has been repeatedly acclaimed as the King of Fruits [1]. Mango belongs to the family Anacardiaceae is a tropical to sub-tropical fruit, originated in the Indian sub-continent (Indo-Burma region) in the prehistoric times. Nowadays, it is the most important economic and delicious fruit in hilly area of Bangladesh [2]. The Integrated Nutrient Management (INM) is the maintenance of soil fertility for sustaining increased crop productivity through optimizing all possible sources, organic and inorganic, of plant nutrients required for crop growth and quality in an integrated manner, appropriate to each cropping system and farming situation in its ecological, social and economic possibilities [3]. Chundawat [4] reported that one characteristic of the INM is that the fertilizer recommendation should take into account the cropping system as a whole rather than individual crop in the system. This aspect is particularly important in case of phosphorous where the percentage utilization by the crop to which it is applied is rather low and where there is residual effect to benefit the following crop. Similarly, the nitrogen contribution of legume crops in the cropping system will have to be considered. Besides, some crops show selective uptake of some specific elements. Moreover, nutrients supplied from other sources should be accounted for making up the gap between the recommended and actual levels of fertilizer application. In the recent years, intensive crop cultivation using high yield varieties of crop with imbalanced fertilization has led to mining out scarce native soil nutrients to support plant growth and production, the dominant soil ecological processes that severely affected the fertility status and production capacity of the major soils in Bangladesh. Available data indicated that the fertility of most of our soils has deteriorated over the years [5,6] which is responsible for national yield stagnation and in some cases, even declining crop yields Cassman et al. [7]. The use of chemical fertilizers mainly for NPKS has been increasing steadily but they are not applied in balanced proportion. For example, in 1996- 421:71:454:44 million tons of NPKS, respectively, were removed in grain and straw while in the same year 507:119:114:13 million tons were added in the form of inorganic fertilizers. Considering, the recovery percentage of the added nutrients the gap was about 244:47:400:41 million tons of NPKS [8].

Moreover, emerging deficiency of micronutrients like Zn, B, Mn, Mo has been reported in some parts of the country particularly northwestern region. It is now well known that S and Zn deficiencies particularly in wet land rice soils in many parts of the country have been induced by imbalanced fertilization. Deficiencies of Ca and Mg are also prevalent in calcareous soils. On the other hand, organic matter content of most of the Bangladesh soils is very low where the majority fall below the critical level (1.5 percent). The organic matter content of Bangladesh soils in continuously cropped areas from 1967 to 1995 has been depleted by 5 to 36 percent [9]. One natural reason is that organic matter decomposition in soils with tropical climate, like Bangladesh, is high. Moreover, the addition of organic materials to soil through FYM, compost and organic residues has been reduced considerably because a major portion of these organic residues (cow dung & crop residue) is used up as fuel by the rural people. The Northern and North-western parts of Bangladesh are well known for better mango production [10]. Hilly area is one of the districts of these parts. A good percentage of farmers in this district depend on mango production as the major source of income but no study was conducted on mango production by integrated nutrient management as well as on growers in this area. This is why study was conducted in the district. From the experimental view the experiments was studied to identify better combination of organic and inorganic fertilizer packages for sustainable productivity of mango in hill.

2. MATERIALS AND METHODS

2.1 Site Description

The experiment was conducted in the mango garden in three hilly Districts in Bangladesh during the period from 15 October 2015 to 30 May 2017. The experimental area is located in Hill Tracts (CHT); the only extensive hilly area in Bangladesh lies in southeastern part of the country (210 25' N to 230 45' N latitude and 910 54' E to 920 50' E longitude) bordering Myanmar on the southeast, the Indian state of Tripura on the north, Mizoram on the east and Chittagong district on the west. It belongs to Bandarban, Khagrachari and Rangamati under the AEZ 29 (Northern and Eastern Hills Tract). The soil texture is sandy loam and silty loam with pH 4.0-5.5.

2.2 Experimental Design

The three factor experiment was laid out in the randomized block design with three replications. There are four treatments Mango (5-10 yrs. old). The treatments are: 4 (four) Fertilizer packages * $T_1 = \text{Control}$, $T_2 = N_{230}P_{53}K_{100} S_{36}Zn_3 B_4 + \text{CD/Compost } 20000 \text{ g/plant}$, $T_3 = 125\% \text{ of } T_2$ and $T_4 = 150\% \text{ of } T_2$. Each row was used as a block. In addition, cow dung and mustard oil cake was applied at the rate of 2 kg and 2 kg plant⁻¹. Manures and 50% of the inorganic fertilizers were applied in October 2015 by digging rings around the trees. Rest 50% of the inorganic fertilizer was applied again during March 2016 in the same ring around the trees before fruit setting. Two irrigations (I2) were given, one after first application of fertilizer and another after second application of fertilizer. In case of one irrigation, it was applied after first application of fertilizer. The base of the trees were kept weed free during the period of experimentation. Preventive measures were taken by applying cypermethrin (Ripcord/Cymbush/Arrivo) 10EC at the rate of 1.0 ml/litre before and after fruit setting to control the insect pest like mango mite, caterpillar, mango fruit borer etc. Precautionary measures against disease infestation especially mosaic virus and fruit root were taken by spraying Dithene M-45 @ 4.5 g/litree at the time of flowering. Fruits were harvested when they attained full maturity indicating fruit colour changes from greenish to yellowish red. Harvesting was done from 15 May to 24 May 2005. Ten panicles from each plant were selected at random and observations were made on fruit set, fruit drop, fruit length, fruit diameter and fruit weight. Fruit quality was determined by panel test method. Fruits plant⁻¹ and fruit yield were obtained by counting and weighing all the mango harvested from each plant, respectively. The data were analyzed statistically by means of computer package MSTAT. The differences among the treatment means were adjudged by the Duncan's Multiple Range Test (DMRT) as outlined by Gomez and Gomez [11].

3. RESULTS

3.1 Effects of Integrated Nutrient Management on the Performance of Mango in Hills (Khagrachari Site)

Data on Table 1 showed the yield of mango. Mango yield were varied from 7.72-22.30 kg/plant. The highest mango yield 22.30 kg/plant

found in T_4 treatment (150% of T_2) which was statistically similar with T_3 treatment (125% of T_2). And the lowest yield 7.72 kg/plant was observed in T_1 treatment that received no fertilizer which was statistically similar with T_2 treatment. Average TSS% was measured and that was 17.5%. The increase in fruit set in the present studies might be due to maximum availability of nutrients in the rhizosphere with integrated application of bio-organic and chemical fertilizers or their cumulative effect have increased translocation of metabolites from roots to flower to enhance pollen germination and pollen tube growth [12].

Table 1. Yield of mango kg per plant (Khagrachari site)

Treatment*	Yield (kg plant ⁻¹)
T_1	07.72b
T_2	10.84b
T_3	16.67a
T_4	22.30a
LSD	6.11
CV%	14.78

* $T_1 = \text{Control}$, $T_2 = N_{230}P_{53}K_{100} S_{36}Zn_3 B_4 + \text{CD/Compost } 20000 \text{ g/plant}$, $T_3 = 125\% \text{ of } T_2$ and $T_4 = 150\% \text{ of } T_2$

3.2 Effects of Integrated Nutrient Management on the Performance of Mango in Hills (Bandarban Site)

Data on Table 2 showed the yield of mango. Mango yield were varied from 24.13-48.25 kg/plant. The highest mango yield 48.25 kg/plant found in T_3 treatment (125% of T_2). And the lowest yield 24.13 kg/plant was observed in T_1 treatment that received no fertilizer which was statistically similar with T_2 treatment. Average TSS% was measured and that was 18.00%.

Table 2. Yield of mango kg per plant (Bandarban site)

Treatment*	Yield (kg plant ⁻¹)
T_1	24.13 ^c
T_2	29.38 ^c
T_3	48.25 ^a
T_4	39.30 ^b
LSD	8.02
CV%	10.41

* $T_1 = \text{Control}$, $T_2 = N_{230}P_{53}K_{100} S_{36}Zn_3 B_4 + \text{CD/Compost } 20000 \text{ g/plant}$, $T_3 = 125\% \text{ of } T_2$ and $T_4 = 150\% \text{ of } T_2$

3.3 Effects of Integrated Nutrient Management on the Performance of Mango in Hills (Rangamati Site)

Data on Table 3 showed the yield of mango. Mango yield were varied from 9.62-23.10 kg/plant. The highest mango yield 23.10 kg/plant found in T_4 treatment (150% of T_2) which was statistically similar with T_3 treatment (125% of T_2). And the lowest yield 9.62 kg/plant was observed in T_1 treatment that received no fertilizer which was statistically similar with T_2 treatment. Average TSS% was measured and that was 18.5%.

Table 3. Yield of mango kg per plant (Rangamati site)

Treatment*	Yield (kg plant ⁻¹)
T_1	9.62b
T_2	11.84b
T_3	14.17a
T_4	23.10a
LSD	4.12
CV%	15.21

* T_1 = Control, T_2 = $N_{230}P_{53}K_{100}S_{36}Zn_3B_4 +$ CD/Compost 20000 g/plant, T_3 = 125 % of T_2 and T_4 = 150 % of T_2

4. DISCUSSION

The nutrient balance system has two parts: inputs that add plant nutrients to the soil and outputs that export them from the soil largely in the form of agricultural products. Important input sources include inorganic fertilizers; organic fertilizers such as manure, plant residues, and cover crops; nitrogen generated by leguminous plants; and atmospheric nitrogen deposition. Nutrients are exported from the field through harvested crops and crop residues, as well as through leaching, atmospheric volatilization, and erosion [13]. The difference between the volume of inputs and outputs constitutes the nutrient balance. Positive nutrient balance in the soils (occurring when nutrient additions to the soil are greater than the nutrients removed from the soil) could indicate that farming systems are inefficient and in the extreme, that they may be polluting the environment [14]. Negative balance could well indicate that soils are being mined and that farming systems are unsustainable over the long-term. In case of negative nutrient balance, nutrients have to be replenished to sustain agricultural outputs and to maintain soil fertility for future. Sustainable agricultural production

incorporates the idea that natural resources should be used to generate increased output and incomes, especially for low income groups without depleting the natural resource base. INM's goal is to integrate the use of all natural and man-made sources of plant nutrients, so that crop productivity increases in an efficient and environmentally benign manner, without sacrificing soil productivity of future generations [15]. INM relies on a number of factors, including appropriate nutrient application and conservation and the transfer of knowledge about INM practices to farmers through extension personnel.

The increase in productivity of horticultural produce removes large amounts of essential nutrients from the soil. Without proper management, continuous production of crops like mango reduces nutrient reserves in the soil. Another issue of great concern is the sustainability of soil productivity in hilly area, as land began to be intensively exhausted to produce higher yields. Overtime, cumulative depletion decreases production, yield and soil fertility and lead to soil degradation.

On the other hand, excess supply or continuous use of inorganic fertilizers as source of nutrient in imbalanced proportion is also a problem, causing economic inefficiency, damage to the environment and in certain situations, harm the plants themselves and also to human being who consume them [16]. The new approach to farming often referred to as sustainable agriculture, seeks to introduce agricultural practices that are ecofriendly and maintain the long term ecological balance of soil ecosystem. The integrated nutrient management is considered as the alternative source to meet the nutrient requirement of the mango cultivation. The continuous use of chemical fertilizers has degraded the soil health in terms of fertility and has also caused soil pollution. The reduction in the soil fertility has resulted in low productivity of the crop. Besides, the increasing cost of fertilizers and their negative effect on soil health has led to intensified attempts to the use of bio fertilizers and cow dung along with inorganic fertilizers. The integrated nutrient management infuses long term sustainability in the productivity level because of availability of nutrients in soil for next season crop. Incorporation of organic fertilizers is a common practice to improve the yield of mango fruit crops. It also limits chemical intervention and finally minimizes the negative impact on the wider environment. Due to the high

cost of chemical fertilizers and poor purchasing capacity, integrated nutrient management have been used for their ecofriendly and beneficial effect on environment and fruit crops. Kirad et al. [17] reported in mango that the maximum fruits per plant (8.77) and fruit yield per hectare (8.07 t) were recorded with 75 percent recommended fertilizers rate + 25percent vermicompost + rhizosphere bacteria culture treatment. Mitra et al. [18] carried out an experiment with newly planted guava cv. Sardar to evaluate the effect of different organic (neem cake, farm yard manure, vermicompost) and inorganic fertilizers as well as biofertilizers on fruit set and yield. They recorded that the application of 50 g N, 40 g P₂O₅ and 50 g K₂O per plant per year along with 10 kg of farmyard manure and 20 kg of Azotobacter per tree per year recorded the maximum fruit set (45.5%). Balakrishna et al. [19] while working with custard apple, recorded highest fruit yield with the application of phosphobacteria and 50 percent recommended dose of NPK.

Yield is a complex character of mango which involves the interaction of several intrinsic and external factors. It largely depends upon the production and mobilization of carbohydrates, uptake of nutrients and water from the soil and the hormonal balance, in addition to several environmental factors to which tree is exposed during the growing period. Yield has been significantly affected by various treatments during the course of investigation. Increase in shoot growth is due to increased nutrient availability (N, P, K and micronutrients) by the stimulative activity of microflora in the rhizosphere and it enhance vigorous growth of plant. The increase in vegetative and yield growth could be attributed to the higher amount of nutrients and some growth stimulating substances excreted by earthworms in their casts and biofertilizers (Azotobacter and PSB). Better growth in organic culture has been reported due to enhancement in soil microbial activity leading to higher N-fixation and phosphate mobilization which corroborated the present findings [20]. The similar finding was also reported by Thakur and Thakur [21]. Chauhan [22] reported that integrated application of organic manures along with chemical fertilizers gave better option for enhancing the growth of plum trees. She reported that the highest growth of plum trees was recorded with the application of 80 percent recommended dose of fertilizer + 20 kg vermicompost + 60 g biofertilizers. Nowsheen et al. [23] studied the effect of integrated nutrient management on strawberry

cv. Senga Sengana. The treatments comprised of 5 nutrient organic treatment combinations including the recommended dose of N, P and K through chemical fertilizer as control.

5. CONCLUSION

Sufficient and balanced application of organic and inorganic fertilizers is a major component of INM. However, the following research findings on INM technology in different soils on mango cultivation, cropping system/patterns of Bangladesh clearly revealed the benefits of INM in respect of yield sustainability and improvement of soil fertility. However, targeting high yield with a high cropping intensity is the most logical way to raise the total production from the country's limited resources. Since the nutrient turnover in soil plant system is considerably high in intensive farming, neither the chemical fertilizers nor the organic and biological sources alone can achieve production sustainability. Even with balanced use of chemical fertilizers high yield level could not be maintained over the years because of deterioration in soil physical and biological environments due to low organic matter content in soils. In this context and as a further response to economic recession, and also to conserve and improve soil fertility the concept of Integrated Nutrient Management (INM) system has been adopted in mango cultivation in hilly area of Bangladesh. The following future studies should be undertaken, covering more dimensions in related matters:

- The study was conducted on the farmers of three hill districts. Similar studies may be undertaken in other parts of the country to verify the findings of the present study.
- The study investigated relationship of the farmers with only one dependent variables in mango production. Further research should be undertaken for exploring relationship of other characteristics of the farmers with other dependent variables.

ACKNOWLEDGEMENT

I would like to express my deepest thanks and boundless gratitude of CRP-1, Hill Agriculture Project, Component II, and Sustainable Land Management for organizing the research work and Krishi Gobeshona Foundation (KGF) for their economic help to get the opportunity as a Scientific Officer during research period.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

- Ahmed AKMA. Production technology of mango. horticultural research centre, BARI, Joydebpur, Gazipur 1701, Bangladesh. 1994;122.
- Talukder I. On Farm Survey in 6 Mango Growing Upazila of Chapainowabgonj District. Bangladesh Journal of Extension Education. 1991;6:65-7.
- Roy RN. FAO, fertilizer programme with special reference to integrated plant nutrition system. Fertilizer in agricultural development. Krishak Bharati Cooperative Limited, New Delhi, India. 1986;149-169.
- Chundawat BS. Integrated nutrient management in tropical and subtropical fruits. Indian J. of Horticulture. 2001; 58(1&2):59-69.
- Karim ML. Relationships of selected characteristics of mango growers with their problem confrontation. M. Sc. Thesis. Bangladesh Agricultural University, Mymensingh. 2001;12-17.
- Ali MM, Shaheed SM, Kubota D. Soil degradation during the period 1967-1995 in Bangladesh. II. Selected chemical characters. Soil Sci. Plant Nutrition. 1997; 43:879-890.
- Cassman KG, de Datta SK, Oik DC, Alcantra J, Sason M, Descalsota J, Dizon M. Yield declined and the nitrogen economy economy of long-term experiment on continuing, irrigated rice system in the tropics. pp. 181-222. In: R. Lal and B.A. Stewart (eds.) soil Management: Experimental Basis for sustainability and environmental quality. Lewis Publisher, London, UK; 1995.
- Islam MF, Haq MF. Integrated nutrient management with inorganic fertilizers and green manure in some doinant cropping patterns. In proceedings of the national workshop on integrated nutrient management for crop production and soil fertility. 24-25 March, 1998. BARI, Gazipur, Bangladesh. 1998;55-71.
- Smaling EMA. Soil nutrient depletion in Sub-Saharan Africa. In the role of plant nutrients for sustainable food crop production in Sub-Saharan Africa, ed. H. Van Reuler and W.H. Prims. Leidschendan, the Netherlands: VKP; 1993.
- Bhuiyan AJ, Roy AK, Ganguly AK. Fruit tree management and improvement; A technical research manual. Local Initiatives for Farmers' Training (LIFT), A Project of CARE, Bangladesh. 1999;7.
- Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Willey and Sons, New York. 1984;397-411.
- Singh S, Nag SK, Kundu SS, Maity SB. Relative intake, eating pattern, nutrient digestibility, nitrogen metabolism, fermentation pattern and growth performance of lambs fed organically and inorganically produced cowpea hay-barley grain diets. Trop. Grassl. 2010;44:55-61.
- Baksh H, Yadav R, Dwivedi R. Effect of INM on growth, yield and yield attributing characters and quality of guava cv. Sardar. Prog. Agric. 2008;8(2):141-144.
- Soni S, Amit K, Rajkumar C, Praval SC, Rahul K, Saurabh D. Effect of organic manure and biofertilizers on growth, yield and quality of strawberry (*Fragaria X ananassa Duch*) cv. Sweet Charlie, Journal of Pharmacognosy and Phytochemistry. 2018;2:128-132.
- Gruhn P, Goletti F, Yudelman M. Integrated nutrient management, soil fertility, and sustainable Agriculture: Current issues and future challenges. International food policy research institute, Washington, D.C., USA. 2000;3-31.
- BARC. Land Degradation situation in Bangladesh. Soils Division, Bangladesh Agricultural Research Council, Dhaka 1215; 1998.
- Kirad KS, Barche S, Singh DB. Response of integrated nutrient management in strawberry. Acta Hort. 2010;842:377-380.
- Mitra SK, Gurung MR, Pathak PK. Integrated nutrient management in high density guava orchards. Acta Hort. 2010; 849:258-263.
- Balakrishnan S, Selvarajan M, Siddeswaran K. Effect of biofertilizers in custard apple. South Indian J. Hort. 2001; 49:185-186.
- Korwar GR, Pratibha G, Ravi V, Palanikumar D. Influence of organics on growth, yield of aonla (*Emlica officinalis L.*) and soil quality in semi-arid tropics. Indian Journal of Agricultural Sciences. 2006; 76(8):457-461.

21. Thakur N, Thaur BS. Studies on the effect of integrated nutrient management on growth and yield of plum cv. Santa Rosa. The Asian Journal of Horticulture. 2014; 9(1):112-115.
22. Chauhan, Archana. Studies on integrated nutrient management in plum cv. Santa Rosa. Ph.D. Thesis. Dr Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. (INDIA); 2008.
23. Nowsheen N, Singh SR, Khalie A, Jabeen M, Majeed S. Yield and growth of strawberry cv. SenhgaSengana as influenced by integrated organic nutrient management system. Environ. & Ecol. 2006;24(3):651-654.

© 2020 Zonayet et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/57721>