SOIL NUTRIENT DYNAMICS AS INFLUENCED BY ORGANOMINERAL FERTILIZERS AND TEA SEEDLING NUTRIENT UPTAKE IN NIGERIA

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Abstract

Cocoa husk, cow dung, poultry droppings, siam weed - Chromolaena odorata and tea fluff are common farm wastes in Nigeria. They were used as manures as sole and in combination with inorganic fertilizer as organominerals (OMF), compared to NPK (5:1:1) a reference fertilizer, to supply 150 kg N ha⁻¹ to potted tea seedlings in the open nursery space at Ibadan (lowland ecology) and Kusuku (highland ecology) of Nigeria. The manure based fertilizer treatments resulted in significantly (P<0.05) higher tea dry matter yield than the reference fertilizer - NPK (5:1:1) and between 44.5 - 146 % at Ibadan (lowland ecology) and 29.9 - 233 % at Kusuku (highland ecology) than the control (without fertilizer). Tea plant nutrient uptake, residual soil nutrient and organic matter build-up were more in the organic based fertilizers treatments compared to NPK.

Introduction

Tea (Camellia sinensis L) is the cheapest and most common beverage drink in Nigeria. Local tea production accounts for less than 20 % of total consumption, while more than 80 % of the balance is imported (Esan, 1996). Commercial tea production is localized to the Mambilla Plateau, with limited land for plantation expansion but research has indicated the feasibility of producing tea in the lowland areas that cut across three agro-ecological zones (south west, south east and north east). In all the zones, the soils are highly leached with very low soil N, available P and basic elements (Ipinmoroti, 2006). Presently, quantity of tea produced in Nigeria is inadequate to meet the demand of local tea processing industries, due mainly to soil nutritional problems. Hence, there is need for adequate fertilizer application for optimum tea production on these soils.

In Nigeria, inorganic fertilizers are in short supply, costly and not affordable by farmers (Adeoye et. al., 2005). The soils are equally low in organic matter content, which, as it is for other tropical soils, is the determinant factor of soil fertility and main nutrient storage depot of the soils. It contributes about 30 - 80 % of the cation exchange capacity (CEC) of Nigerian soils (Ayoola and Agboola, 2002) because the soils are dominated mainly by kaolinitic (1:1) clay type with less than 10 % CEC with persistent low crop yields being experienced by farmers. Research effort was therefore geared towards the use of organic based nutrient sources on tea field, to alleviate the problems of the farmers in terms of reduced production cost and to maintain good soil conditions over a long period of usage on a sustainable basis. This paper presents the result of an experiment on the effect of organic nutrient sources, with and without chemical fertilizer supplement, compared to NPK (5:1:1), the reference fertilizer, as nutrient supply to tea plants at Ibadan and Kusuku (lowland and highland) areas in Nigeria.
SOIL NUTRIENT DYNAMICS AS INFLUENCED

Materials and methods
Five readily available farm wastes of plant (cocoa husk, siam weed and tea fluff) and animal (cow dung and poultry droppings) origins were collected from plantations (cocoa husk and siam weed – Chromolaena odorata), factories (tea fluff), abattoir (cow dung) and poultry pens (poultry droppings), where they are generated in large quantities but with disposal problem. The manure samples were wet digested and analyzed for their phosphorus, potassium, calcium and magnesium contents according to IITA (1979). Nitrogen was determined by the kjeldahl method. The soils for the pot experiment were collected from fallowed plots previously cultivated to arable crops in mixed cropping system at Ibadan and Kusuku and analyzed for nutrient contents. Total nitrogen was by kjeldahl apparatus, available phosphorus by Bray’s 1 method (Bray and Kurtz, 1945). The exchangeable cations were extracted with 1N ammonium acetate and determined using atomic absorption spectrophotometer (AAS). The farm wastes were pulverized and used as manure. Their application was based on the nitrogen contents, used alone and in mixture with NPK (5:1:1) as organomineral fertilizer (OMF) at ratios 3:1 (OMF,) and 1:1 (OMF,). The reference fertilizer (NPK 5:1:1), was compounded from the mixture of urea for N, single super phosphate (SSP) for P and muriate of potash (MOP) for K. Ten liter sized black plastic pots were filled with 10 kg soils and about one year old tea seedlings of similar sizes, raised in 1 kg soil in polythene bags were transplanted into the pots. There were five manures, five OMFs, one NPK (5:1:1) and control (no fertilizer, for a total of twelve treatments replicated 4 times in a randomized complete block design (RCBD). The fertilizers were applied at equivalent rate of 150 kg N ha⁻¹. The pots were watered twice per week and hand weeded every 3 months. After 18 months of growth, the tea seedlings were uprooted, washed fresh, dried to constant weight in the oven at 70 °C, weighed and milled. Representative samples were taken, wet digested and analyzed. Nutrient uptake in the tea plants were calculated using the formula:

\[
\text{Uptake} = \text{Dry matter yield} \times \text{nutrient content.}
\]

Soils in pots were removed, sample taken, air dried and analyzed. Tea dry matter yield and nutrient uptake values were subjected to ANOVA and mean differences separated by Duncan multiple range test (DMRT) at P<0.05.

Results
The pre-planting soil nutrient contents at Ibadan and Kusuku respectively were 1.1 and 1.7 g/kg N; 4.63 and 2.15 mg/kg P; 0.63 and 1.31 cmol/kg K; 1.65 and 2.41 cmol/kg Ca; 0.31 and 0.39 cmol/kg Mg; 1.42 and 1.72 g/kg OC. These levels of the nutrients in the soils were considered too low for sustainable tea cultivation when compared with their calculated critical values (Egbe et al., 1989). The low nutrient levels are typical of most tropical soils (Sander, 2002). The soils would therefore need nutrient addition for optimal crop performance. The analytical results of the farm wastes showed that the nutrient contents were between 0.29 - 3.54 % N, 0.15 - 1.55 % P, 0.83 - 3.96 % K, 0.64 - 3.55 % Ca and 0.23 - 0.54 % Mg (Table 1). The C-to-N ratio was between 8.7 - 25.6, thus indicating that they could easily decompose and release nutrients for plant use.

<table>
<thead>
<tr>
<th>Nutrient (%)</th>
<th>Cocoa husk</th>
<th>Cow dung</th>
<th>Poultry droppings</th>
<th>Siam weed</th>
<th>Tea fluff</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>1.46</td>
<td>1.29</td>
<td>3.54</td>
<td>2.47</td>
<td>2.92</td>
</tr>
<tr>
<td>C</td>
<td>37.38</td>
<td>16.51</td>
<td>30.80</td>
<td>42.98</td>
<td>36.50</td>
</tr>
<tr>
<td>C/N</td>
<td>25.60</td>
<td>12.80</td>
<td>8.70</td>
<td>17.4</td>
<td>12.5</td>
</tr>
<tr>
<td>P</td>
<td>0.15</td>
<td>0.60</td>
<td>1.55</td>
<td>0.21</td>
<td>0.30</td>
</tr>
<tr>
<td>K</td>
<td>3.96</td>
<td>0.83</td>
<td>1.83</td>
<td>3.08</td>
<td>2.16</td>
</tr>
<tr>
<td>Ca</td>
<td>0.77</td>
<td>1.57</td>
<td>3.55</td>
<td>1.21</td>
<td>0.64</td>
</tr>
<tr>
<td>Mg</td>
<td>0.33</td>
<td>0.43</td>
<td>0.54</td>
<td>0.76</td>
<td>0.23</td>
</tr>
</tbody>
</table>

The fertilizers resulted to significantly (P<0.05) higher tea dry matter yield (DMY) than control at both locations, while manures and OMFs were generally higher than NPK (Table 2). The
values were between 44.5 - 248 % and 29.4 - 125 % higher than the control at Ibadan and Kusuku respectively. The DMY from manure based fertilizer treatments indicated that CD followed by TF were more outstanding at Ibadan, while it was PD followed by CH at Kusuku (Table 2). The OMF of TF and PD were best at Ibadan; while it was TF based OMF, and CH based OMF, at Kusuku. It thus showed location differences in response of the tea seedlings to the fertilizer types. The Kusuku values were generally higher than the corresponding treatments at Ibadan. The DMY values were in similar trends with values reported by Wanyoko and Mwakha (1991) in Kenya and by Ipinmoroti et al. (2002) in Nigeria, when manures were used on tea seedlings both as alone and in mixtures with mineral fertilizers. The results indicated that the organic based fertilizers are better storehouse for essential nutrients and their subsequent supply to plants (Adeoye et al., 2005). Better performance of tea seedlings under organic based fertilizers may stem from additional supply of Ca, Mg and micronutrients, essential for optimal tea growth, but are lacking in the NPK (5:1:1). The cow dung, poultry droppings, siam weed - Chromolaena odorata and tea fluff were better utilized as OMF, and cocoa husk as OMF, at both locations.

Manures and OMFs were generally superior to NPK and control in enhancing N, P, K, Ca and Mg uptake by tea seedlings (Table 3). Probably due to slow and steady nutrient release by the organic nutrient sources, which were readily made available compared to the fast released and easily leached nutrients from NPK.

Similar observations have been reported for tea and coffee seedlings (Wanyoko and Mwakha, 1991; Obatolu, 1991). Nutrient uptake at Kusuku were significantly (P<0.05) higher than at Ibadan. Except for CH, OMFs were optimal at 3:1 mixtures.

Soil N content after 18 months of tea cropping was higher at Kusuku than at Ibadan, probably due to the warmer weather conditions at Ibadan which must have resulted in higher N volatilization and losses. Soil N at both locations was however higher than the pre-planting soil nutrient contents, for all the manure based fertilizer treatments, while NPK and control led to lower N contents (Table 4). Similar trend was observed for the soil available P, exchangeable K, Ca and Mg at both locations.
SOIL NUTRIENT DYNAMICS AS INFLUENCED BY MANURE TREATMENTS

The soil OC increased from 1.42 g/kg at Ibadan to a range of 2.2-3.1 g/kg and from 1.71 g/kg at Kusuku to a range of 2.9-4.3 g/kg under manure treated soils. The values were reduced to 1.35 and 1.22 g/kg for NPK and control at Ibadan; to 1.67 and 1.55 g/kg for same treatments at Kusuku. The OMF₁ was more effective than OMF₂ on soil nutrient and OC builds up soil nutrient and organic carbon status after tea cropping showed that continuous tea production with sole use of NPK as nutrients source would in the long run lead to soil physical, chemical and eventually, biological degradation and impoverishment. Soil fertility management that would improve the soil organic matter (SOM) is needed for tropical soils, Nigeria inclusive, because of the inherent low SOM, clay contents of mostly kaolinitic (1:1) type and low CEC (Ogunwale et al., 2002). The results indicated that without organic based nutrient addition to the soils, there would be threat to sustainable tea production. There is need for Mg supply under NPK and the control to prevent manifestation of Mg deficiency. This amendment is very much needed, particularly for the Kusuku soil where initial soil K/Mg ratio was much higher than 2, indicating K and Mg nutrient imbalance which can lead to Mg deficiency.

Conclusion
Response of tea to the fertilizers showed that their addition is needed for optimal tea production on the soils. Manures and their combined use with NPK resulted in better soil nutrient condition, tea growth and nutrient uptake than NPK. Cow dung, poultry droppings, siam weed (Chromolaena odorata) and tea fluff were optimal at OMF₁, and cocoa husk at OMF₂ are recommended.

Acknowledgement
The Director, CRIN, Ibadan is acknowledged for permission to publish this work.

References


Protective Effects of Tea on Human Health

Editors: N K Jain, International Society of Tea Science, New Delhi, India, M Siddiqi, Bose Institute, Kolkata, India and J Weisburger, Institute for Cancer Prevention, American Health Foundation, USA

Price: £65.00 (US$130.00) Market Rights: World Exclusive

Readership: Researchers, advanced students and professionals in nutritional sciences, medicine and the beverage industries.

Main Description
Bringing together the latest research from leading experts, this book provides an indispensable reference on the health benefits of drinking tea. It examines the general health giving properties of tea before moving on to a detailed review of the evidence for the beneficial effects of tea on specific ailments including cancer, the common cold, renal disease, cardiovascular diseases, viral afflictions like influenza and SARS, arthritis, lung and pulmonary ailments, aging, oral health, and dementia. The book concludes by challenging misconceptions of the effects of tea. For more information please visit ISTS website <WWW.teascience.org> under Publications -- Books.

Contents (20 chapters in two parts)

Part I: General Protective Effects of Tea
1. Tea is a Health Promoting Beverage in Lowering the Risk of Premature Killing Chronic Diseases, Weisburger
2. Tea is a Rasayana, B N Dhawan, Lucknow, India
3. Health Properties of Tea Catechins, Y Hara, Mitsui Norin Co. Ltd., Japan
4. Bioavailabilities of Tea Polyphenols in Humans and Rodents, J D Lambert, J Hing, H Lu, X Meng, M Lee and C S Yang, The StateUniversity of New Jersey, USA
5. Immunomodulatory Activity of Tea, J Singh and G N Qazi, CSIR, India
6. Antigenotoxic Activity of Tea, Y Shukla and A Arora, Industrial Toxicology Research Centre, Lucknow, India
7. Methodological Issues in Population Studies of Tea and Disease Prevention, I A Hakim, University of Arizona, USA

Part II: Protective Effects of Tea against Specific Ailments
8. Protective Effects of Tea against Cardiovascular Diseases, S. Wiseman, I Zijl, P Weggemans and A Rietveld, Unilever Food and Health Research Institute,
9. Potential Targets of Tea Polyphenols in Cancer Prevention: Significance in Angiogenesis, Metastasis and Apoptosis as well as in Protection of Host Defence System, T Das, G Sa and M Siddiqi, Bose Institute, Kolkata, India
10. The Beverage Tea in Chemoprevention of Prostate Cancer, M. Saleem, I A Siddiqi and H Mukhtar, University of Wisconsin, USA
11. Anti-Diabetic Effects of Tea and its Constituents, Y K Gupta, C Tripathi and Y Shukla, Industrial Toxicology Research Centre, Lucknow, India
12. Green Tea Catechins against Oxidative Stress of Renal Disease, T P Rao, L R Junjea, Taio Kagoku Co., Ltd., Japan, and Yokozawa, Toyama Medical and Pharmaceutical University, Japan
13. Hepatoprotective Properties of Tea, Y Shukla, N Kaira and Y K Gupta, Industrial Toxicology Research Centre, Lucknow, India
14. Preventive Effects of Tea against Obesity, K Sayama, Shizuoka University, Japan, T Hase, and I Tokimitsu, Kao Corporation, Japan, and I Oguni, Hamamatsu University, Japan
15. Protective Effects of Tea against Lung/Pulmonary Ailments, H Yamoda, University of Shizuoka
16. Anti bacterial and Anti viral effects: influence including SARS, P C Leung, Chinese University of Hong Kong
17. Green Tea and the Prevention of Arthritis, A Ahmed, B B Haleez and T M Haqqi, Case Western Reserve University, USA
18. Chemoprevention Effect of Tea against Neuronal Death-Dementia, T Kakush Itoen Ltd, Japan
19. Chemoprevention Action of Tea against Ageing / Senescence, K Unno, University of Shizuoka, Japan
20. Tea and Oral Health, C D Wu, University of Illinois at Chicago, USA

The book has been released on 2nd October 2006. 15% discount is available on the list price to individuals. The discount is 25% for Libraries, ISTS Members and Associates of International Society of Tea Science. Orders may be placed with the Secretary International Society of Tea Science A-298, Sarita Vihar, New Delhi-110076, India. E Mail <teascience@gmail.com>

Note: For Review Please see Page 31 and 32 Which Follow.
Book Review


The health beneficial properties of tea, the world’s most popular beverage, have gained prominence during the last two decades. In the book, the editors have brought together under once cover, various health-related aspects of tea. The twenty different chapters of the book review varying health promoting benefits and proposed mechanisms of the action of tea. Contributions by eminent scientists and researchers form the various chapters, each of which represents a well-referenced review of evidence from in vitro, in vivo and clinical models on a specific health ailment.

The book is divided into two parts. Part-I, comprising of seven chapters, deals with exhaustive reviews related to general protective effects of tea, whilst Part-II reveals the protective effect of tea against specific ailments.

In different chapters, throughout the book, authors emphasise the protective role played by several important bioactive molecules present in tea. The flavonoids, catechins and polyphenols with their potent antioxidant and scavenging properties, have been demonstrated to exercise their protective actions via multiple mechanisms in different ailments. Epidemiological techniques, supplemented by clinical and laboratory studies conducted on animal models, human volunteers and in vivo studies, provide information of the mechanism of action of tea and its constituents and on its metabolism. Tea has been demonstrated to play a major role in reducing the risks associated with life-style and environment related killer diseases viz, cardiovascular disease, cancer, diabetes, obesity, liver and pulmonary ailments, arthritis, influenza, SARS, dementia, Alzheimer’s and even AIDS.

Though encouraging, the experimental and epidemiological data as elaborated in different studies is still preliminary and hence not conclusive. The researcher should use this valuable information as the basis for further extensive and in-depth studies. Further details on bioavailability of polyphenols of tea in plasma and tissue, coupled with a careful consideration of the factors affecting the bioavailability and design of effective intervention trials are necessary to gain complete understanding of the biological actions of tea.

The contents of each chapter impart precise up-to-date information on the protective role of tea and its constituents in different health ailments, but there tends to be frequent repetition of some contents. This is probably due to the fact that the book is a theme compilation of several authors’ contribution. The lack of a general introductory chapter and a final summary chapter in a compilation, stand out as lacunae.

The defects are minimal and outweighed by the overall utility of this well-presented and well-referenced compilation of information. This book will be especially useful to researchers, health specialists and professionals in the beverage industry. It will undoubtedly be an invaluable asset in scientific and public libraries.

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BOOK REVIEW II for Protective Effects of Tea on Human Health published in Journal of Food Science + Technology Abstracts 39(1) 2007

12007-01-Hn0397

Protective effects of tea on human health.
Book
Authors: Jain, N. K.; Siddiqi, M. A.; Weisberger, J. H. [Editors
Publication year: 2006
Int. Soc. of Tea Sci., New Delhi, India
Publisher address: Nosworthy Way, Wallingford, OX10 8DE, UK; CABI
Publishing. Tel. +44 (0)1491 832111. Fax +44(0)1491 829198. E-mail
ISBN: 1845931112
Refs: many ref.
English
This book on the protective effect of tea on human health is divided into 2 sections:
General protective effects of tea (7 chapters); and Protective effects of tea against specific ailments (13 chapters). Individual chapters include: Tea is a health-promoting beverage in lowering the risk of premature killing chronic diseases: a review (pp. 1-5, 15 ref.); Tea as a Rasayana (pp. 6-15, many ref.); Prophylactic functions of tea catechins (pp. 16-24, 11 ref.); Bioavailabilities of tea polyphenols in humans and rodents (pp. 25-33, 29 ref.); Immunomodulatory activity of tea (pp. 34-44, 48 ref.); Antigenotoxic activity of tea (pp. 45-57, 51 ref.); Methodological issues in population studies of tea and disease prevention (pp. 58-64, 27 ref.); Protective effect of tea against cardiovascular diseases (pp. 65-75, 58 ref.); Potential targets of tea polyphenols in cancer prevention (pp. 7690, many ref.); The tea beverage in chemoprevention of prostate cancer OJp. 9T-101, n ref.; Antidiabetic effects of tea and its constituents (pp. 102-108, 45 ref.); Green tea catechins against oxidative stress of renal disease (pp. 109-119, 57 ref.); Hepatoprotective properties of tea (pp. 120-130, 58 ref.); Protective effect of tea against obesity (pp. 131-148, 50 ref.); Protective effects of tea against lung/pulmonary ailments (pp. 149157,51 ref.); Antibacterial and antiviral effects of tea - from influenza to SARS (pp. 158-171,44 ref.); Green tea and the prevention of arthritis (pp. 172-181,59 ref.); Chemopreventive effect of tea against neuronal death-dementia (pp. 182-191, 52 ref.); Chemopreventive action of tea against senescence/ageing (pp. 192-199, 41 ref.); and Tea and oral health (pp. 200-206, 49 ref.). A 5pp. subject index is included.
Section: Alcoholic and non-alcoholic beverages
Keywords: BOOKS; CROPS; HEALTH; PLANT FOODS; TEA; TEAS