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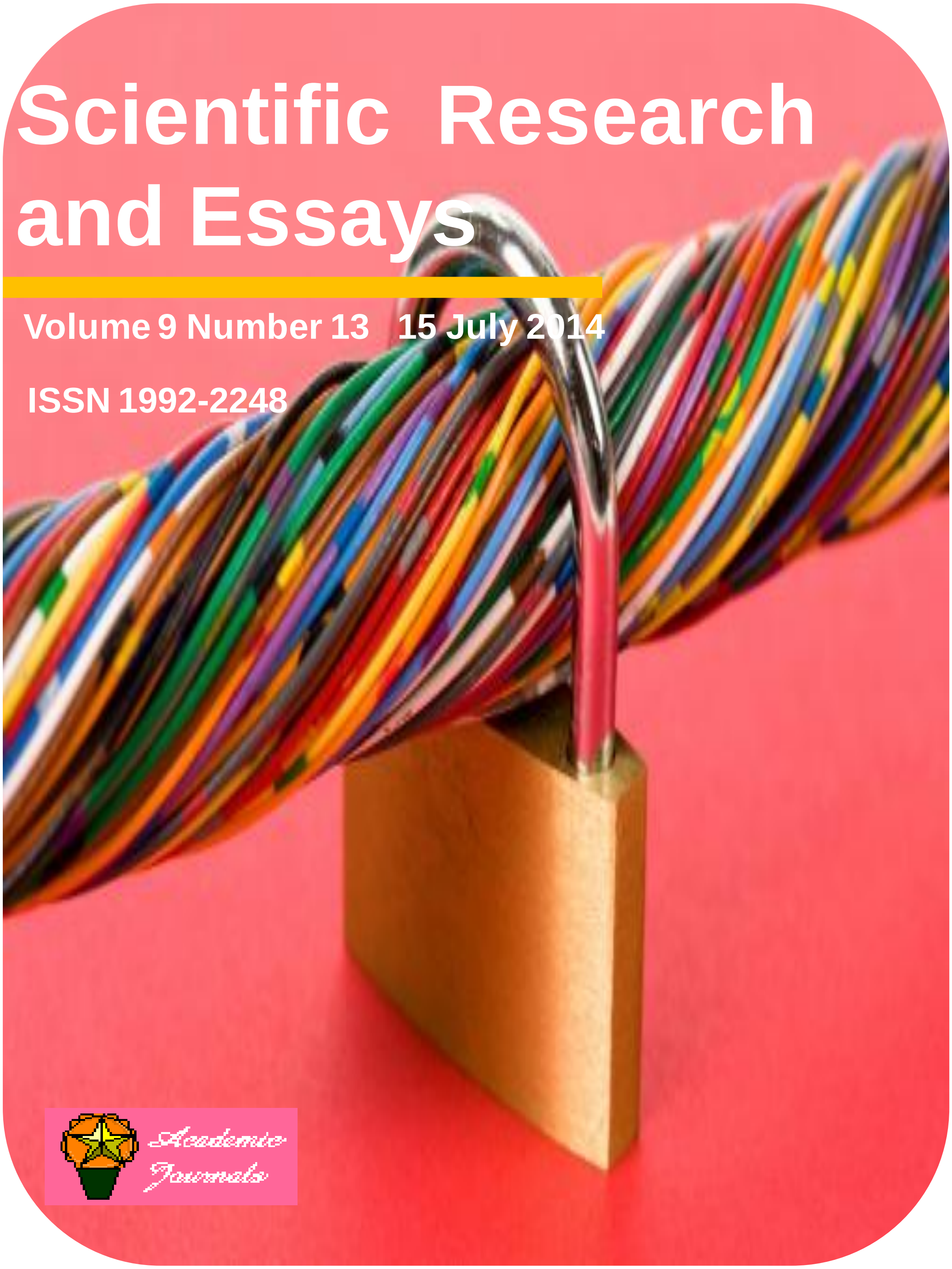

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Scientific Research and Essays

Review

Composting: An opportunity in a carbon conscious world for combating climate change

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Increase of greenhouse gas (GHG) emissions is an ever challenging concern to mitigate global climate change. Governments and corporations across the world have introduced innovative strategies to reduce steadily rising GHG emissions. Some of these strategies are carbon taxes, energy efficiency strategies, command and control policies and market-based pollution trading mechanisms. This review highlighted the concept of carbon cap and trade program, GHG emission from compost, mitigation strategies, and carbon credit opportunities in the developing countries.

Key words: Compost, carbon credits, greenhouse gas (GHG), waste management.

INTRODUCTION

As the debate over global climate change shifts from “is it happening” to “what do we do about it”, composting, like all other waste management activities, is being reviewed through the greenhouse gas (GHG) lens. However, in order to make fair comparisons, we have to compare different activities as both possible sources of GHG and also as possible sinks. Composting would be beneficial if, when compared to alternatives, it either puts less GHG into the atmosphere (avoidance) or takes more CO_2 out of the atmosphere (sequestration). The net benefit can be turned into cash through the sale of “carbon credits” on the emerging carbon trading mark. One of the principal ways of attaining higher productivity and environmental standards are identification and adoption of beneficial management practices (BMP) by reviewing the conventional agricultural activities (Okkan and Fistikoglu, 2013). The BMP are agricultural practices that promote sustainable land stewardship and maintain or increase profitability of farms. The BMP are from both crop and animal production systems and tradeoffs between the two systems could provide several opportunities in reducing, removing and/or avoiding of GHG emission (Asgedom and Kebreab, 2011).

This review article highlights the relevance of composting, and strategies to mitigate global climate change and possibility for carbon credit with following key objectives:

1) What is the basic concept of carbon crediting?
2) Relevance of composting,
3) GHG emission scenarios from the compost,
4) GHG mitigation strategies from compost through alternative management approaches, and
5) Defining the limit of carbon credit through different composting technologies.

We have taken the issues and possibilities of utilizing municipal wastes as composting material in the

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developing countries taking into account of global relevance in waste management.

COMPOSTING IN THE CAP-AND-TRADE PROGRAM

Cap-and-trade regulations limit the quantities of pollutants, (in this case GHG) that entities can emit into the atmosphere, and can provide economic incentives for reducing emissions even further (below the cap). The "cap" sets a limit on GHG emissions, while the "trade" creates a market for carbon allowances. Regulated entities (for example, a coal burning power plant) can either reduce emissions from their own facilities, or can purchase “emission reductions” from other regulated entities that have reduced their emissions below their cap (and therefore have some left over). The major components involved in a cap-and-trade program are caps, coverage, and monitoring. Limit (cap) of GHG emission for any company is set up by international, federal, or local governing body. The government then decides on coverage, or the sectors and sources of carbon that must comply with this limit. To ensure compliance with this cap, systems must also exist to monitor sources, checking and verifying each source’s reporting of carbon output. Sources, however, may go beyond their allowances, or over the cap, if they have traded with another source.

Solid waste management practices practiced in many developing countries release high quantities of GHG in the atmosphere. High GHG emission is mainly due to land filling; thus, solid waste composting sector creates significant opportunities for carbon mitigation, which could eventually become tradable carbon credits. Emission reductions can also be created voluntarily by non-regulated entities (such as a compost facility) to be used by regulated entities to offset their own emissions. The 1992 UN Framework Convention on climate change created that the Kyoto Protocol, was the basis for initial carbon cap-and-trade programs. As of mid 2007, there were 165 pieces of legislation introduced to the 110th congress, of which at least were related to cap-and-trade programs (Kapoor and Ambrosi, 2007). The primary instrument being traded in these programs are “carbon credits”

CARBON CREDITS AND MARKETING OPPORTUNITIES

Carbon credits or carbon offsets usually referred to as certified, tradable GHG emission reductions, used within a cap-and-trade program. Reducing emissions does not automatically create carbon credits - results from a formal process or “protocol” that quantifies, verifies, and certifies qualifying emission reductions from eligible projects. Credible carbon credits as a whole represent real, permanent, quantifiable, verifiable, and enforceable emission reductions. Often carbon credits are formally issued or registered by a carbon “registry” or exchange to facilitate market trading and ensure that the same credits are not sold more than once. Carbon credits are usually quantified in units of metric tons of carbon dioxide equivalents (CO_2 e).

Every tons of CO_2 not emitted is considered as one credit and every carbon credit fetches the firm around $3-6. In Europe it is €5 per tons of CO_2, but is expected to rise to €7.50 during the course of the year 2014. The value will potentially reach to a new high of €180 bn by the year 2016. The carbon credit remuneration continues year after year. And the best part is that it is quite easy to implement technologies known to reduce emissions provided the project meets certain criteria. The firms trading credits have two options to choose from depending on the life of the project - fixed crediting period of 10 years or first period of 7 years extendable twice for a total period of 21 years. Advantage of implanting cleaner and sustainable technologies is the ability to avail funding from prototype carbon fund which is under the Aegis of the World Bank. The fund is formed by contributions from many developed nations. Indian firms may well take the lead to use cleaner technologies to earn credits and secure funds. From 2005 to 2006, the value of the total world market of carbon credits tripled. In 2006, over 1 billion tons of credits, with a market value of about $20 billion, were traded through the European Trading System (by countries that have adopted the Kyoto Protocol) (Kapoor and Ambrosi, 2007). In the U.S., which is not participating in the Kyoto cap-and-trade system, the market is much smaller, but still significant: in 2006 over 10 million tons of carbon traded on the Chicago Climate Exchange (CCX) with a value of over $40 million. Since 2003 CCX prices have ranged from less than a dollar per metric ton to almost $5. Due to international agreements and action on climate change, the carbon market is one of the fastest growing markets for financial commodities.

Amidst growing concern and increasing awareness on the need for pollution control, the concept of carbon credit came into vogue as part of an international agreement, popularly known as the Kyoto Protocol. Carbon credits are certificates issued to countries that reduce their emission of GHG, which causes global warming. It is estimated that 60 to 70% of GHG emission is through fuel combustion in industries like cement, steel, textiles and fertilizers.

IMPORTANCE OF COMPOSTING

With emergence of municipal solid waste (MSW) as a big problem for municipal authorities here in India and abroad, companies introduced indigenously developed equipment to process mixed MSW. Aerobic composting

Table 1. Prevented methane emission (CO_2 equivalent) which otherwise could be claimed as emission reductions (ER) through composting in different places of the world (Gentil et al., 2009).

Name of the country	ER tons CO_2 e year $^{-1}$	Tons per day
Bangladesh (Dhaka)	6814	100
China (Wuzhou)	7022	93
Ivory Coast (Abidjen)	7212	219
Columbia	5570	500
Indonesia (Bali)	27020	700
Delhi (Okhla)	73202	1950

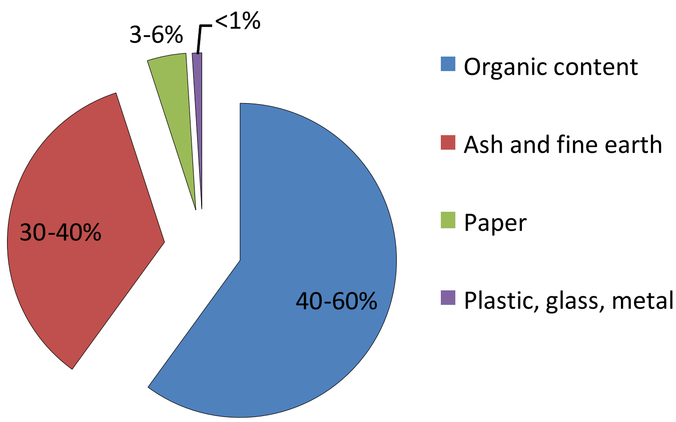

Figure 1. Distribution of waste materials in the municipal solid waste (MSW) source in India (Sharholy et al., 2008).

is one of such technology and it is considered to be one of the cheapest solutions to mixed MSW. Methane emission mitigation potential of compost in different places of the world is given in Table 1. All biodegradable material available in waste is converted into valuable organic manure. Aerobic composting is a process involving bio-chemical conversion of organic matter into humus lignopoteins by mesophilic and thermophilic organisms. A composting process seeks to harness the natural forces of decomposition to secure the conversion of organic waste into organic manure. This process is done under controlled conditions in order to make it aesthetically acceptable, minimize the production of offensive odours, avoid the propagation of insects, destroy pathogenic organisms present in the original waste, destroy weed seeds, retain the maximum nutrient content NPK, minimize the time required to complete the process, and minimize the land area required for the process. Compost serves as an ultimate solution for organic waste disposal, value addition to the project by means of fertilizer generation, easy handling and simple procedure, totally eco-friendly process, support to the green cover in the city, and up-gradation of the natural resources by completing the cycle of nature.

CARBON CREDITS THROUGH COMPOSTING

Carbon credit facilities works with direction of low emissions of GHG or less carbon intensive approaches. Since GHG mitigation projects generate credits, this approach can be used to finance carbon reduction schemes between trading partners around the world. The types of feedstocks, and where they were going before the new composting project, are also important since credits are only valid where real emission reductions (relative to a baseline scenario) occur. In other words, we do not get credit just for composting, but for composting those feedstocks that would otherwise be emitting methane or nitrous oxide into the atmosphere. Formal protocols for quantifying compost-related emission reductions have been developed by the Intergovernmental Panel on Climate Change (IPCC) and are already being used for offset projects within the Kyoto Protocol framework. In the U.S., protocols for the CCX and other programs are being developed. Trading carbon credits between developing and developed nations will soon become a reality. Companies in India will gain monetarily and be able to put up projects that are eco-friendly. The latest comes from quite unconventional quarters - trading of carbon credits or more specifically carbon dioxide credits between developing and developed nations. When global warming is the watchword and reducing carbon dioxide emission is the buzzword, can trade be far behind?

There is close to 5100 odd municipalities across India wherein the problem of MSW management has reached critical dimensions (Figure 1). It is estimated that 377 million urban populations in India (≈31% of the total population) is generating almost 194,000 MT/d of MSW (Sharholy et al., 2008). State-wise solid waste production in India is given in Table 2. The urban local bodies (ULBs) in their efforts to safeguard public health are incurring between Rs. 800-1500/MT of solid waste for collection, treatment and disposal and this activity alone accounts for almost 30 to 50% of a typical municipal budget. There are significant issues related to primary collection, transportation, treatment and safe disposal which impact sustainability and viability of the entire chain

Table 2. Municipal solid waste (MSW) generated from different cities in India (Sharholy et al., 2008).

Name of the state	MSW (tones per day)
Andhra Pradesh	3943
Assam	196
Bihar	1479
Gujarat	3805
Haryana	623
Himachal Pradesh	35
Karnataka	3118
Kerala	1220
Madhya Pradesh	2286
Maharashtra	8589
Manipur	40
Meghalaya	35
Mizoram	46
Orissa	646
Punjab	1001
Rajasthan	1768
Tamilnadu	5021
Tripura	33
Uttar Pradesh	5515
West Bengal	4475
Chandigarh	200
Delhi	4000
Pondicherry	60

of operations. GHG (CH_4 and NO_X) emission from the solid wastes during different year is given in Table 3. A number of ULBs have gone about setting up treatment plants under the paradigm of 'waste to energy' and 'waste to wealth' with the presumption of that being an end in itself. The paradigm of 'safeguarding environment and public health' is often found to be relegated to a secondary level. In most cases, decisions to set up a particular technology solution also appear to have been influenced by other factors. The technologies that have been attempted in India during last 3 decades are windrow composting, mass burn, combustion of refuse derived fuel, bio-methanation, and at a small scale numerous vermicomposting initiatives. However, time and again it is seen that the technology driven initiatives run into rough terrain and perforce do not bring the desired environmental and public health benefits, least of all the financial benefits. A number of institutional, technical and financial risk factors are associated with almost all the resource recovery technologies mentioned above which lead to closure of the facilities within a rather short period after commission.

Okhla composting plant near Delhi, India converts approximately 73,000 tones of MSW into compost every year. This is equivalent to 200 tons of MSW per day. Compost is utilized as organic fertilizer for agricultural purpose. Around 1,600 tons of CH_4 are avoided on average per year. CH_4 has global warming potential; this is equivalent to 34000 tons of CO_2 e year. Not only avoidance of CH_4 emission from composting plant project, the project avoids emission of CH_4 that would be produced by land fill air, and water pollution is also prevented. Therefore, total emission reduction would be 235,000 tons of CO_2 e in the crediting period. And Okhla became the first in India to receive the carbon credits from the United Nations Framework Convention on Climate Change (UNFCCC). The plant received financial assistance in advance against the carbon emission reduction (CER) earnings from this plant.

Composts are rich in long-term carbon in the form of fulvic and humic acids carbon compounds. Compost product is estimated to contain 100 to 150 kg of carbon per cubic meter of product and in the order of 10% or more of this is in non labile/long form such as humic compounds. When this is converted to CO_2-e, the stored carbon benefit of compost is in the order of at least 37 to 55 kg m^{-3} of product. Trading of carbon and NOx emission reduction is an attractive approach to implement cleaner treatment technologies to replace current anaerobic approaches for solid waste management. Kottayam a town in Kerala, India generates 52.6 tons per day as MSW, which would result in 5380 TCO_2 e $year^{-1}$ of GHG emission if dumped. If the same waste was composted aerobically, it may generate 200 t CO_2 $year^{-1}$; hence, a reduction of 5166 t CO_2 e $year^{-1}$. This reduction can lead to the monetary gain for the town on the market price of carbon credit.

The rate of solid waste generation and the corresponding CH_4 emission have increased to an exponential rate since 2001. By the year 2041, the waste will generate about 32 million tons of CH_4 and this waste will require about 1100 km^2 of land for disposal. As composition of MSW in India differs from city to city on wet weight basis the average India MSW consists of organic content, ash and fine earth, paper, glass, metal in different ratios (Figure 1). The calorific value of the Indian MSW is low due to the high inert matter and moisture content and is in the range of 800 to 1000 K Cal Kg^{-1} (Sharholy et al., 2008). The total waste generated in urban India is estimated to be 188,500 tons per day (TPD) or 68.8 million tons per year (TPY). A total of 366 cities in India which represent 70% of India's urban population generate 47.2 million TPY per capita waste generation rates of 500 g/day. At this rate the urban MSW generated in 2041 would be 230 million TPY and would occupy an area equivalent to that Mumbai, Chennai and Hyderabad.

Bangladesh is getting involved in carbon credit trading with the certification of a recycling plant that converts organic waste into compost. Plant collects some 100 tons of vegetable waste from two city markets daily and recycles it through composting. If that waste were dumped in the landfill it could have emitted huge

Table 3. Estimate of annual methane (CH_4) and nitrous oxide (NOx) emission from India 1990 - 2020.

Year	CH_4 emission from land fill (Gg)	NOx emission from manure management (Gg)
1990	334	17
1995	382	18
2000	436	19
2005	498	20
2010	569	20
2015	650	21
2020	743	22

(amounts of) methane gas. The plant currently produces 15,000 tons of compost annually, which is sold inexpensively to rural farmers. The Kyoto Protocol commits most industrialized nations to efforts to reduce GHG emissions that contribute to climate change, in part by investing in emissions-reduction projects in developing countries. The projects received credits that could be traded with industrialized countries, giving the richer countries credit toward their own emissions reduction goals and poorer countries cash. The Asian development bank plans to replicate the organic waste composting model in four other cities in Bangladesh, and the department of the environment is developing five similar projects in cities and municipalities. Waste concern is developing strategies for MSW management in several other Asian countries, including Nepal, Pakistan, Sri Lanka, Cambodia and Vietnam, as well as in Africa.

GREEN HOUSE GAS EMISSION FORM COMPOST

Some GHG emission during composting is unavoidable; however, management practices can reduce those emissions. Manure properties can be modified, e.g., by using bulking material to adjust the C/N ratio and moisture content (Shi et al., 1999), using proper windrow pile dimensions to manage aeration (Fukumoto et al., 2003) and using amendments to change manure pH, available C and N. Adding straw or woodchips (C-rich amendments) will increase the C/N ratio and reduce CH_4 (Yamulki, 2006) and N_2O emission (Mahimairaja et al., 1995; Yamulki, 2006). Adding phosphogypsum (PG), a P fertilizer industry by-product, reduced CH_4 emission (Hao et al., 2005) mainly due to sulfur-reducing bacteria out-competing the methanogens as CH_4 emission decreased exponentially with the total S content in manure. Although the N_2O emission increased with the manure pH decreased from 8.0 to 7.4 by PG addition as N_2O emission is generally greatest around neutral pH, the increases were not significant compared to no amended manure composting (Hao et al., 2005). Adding mature compost as a source of nitrite-oxidizing bacteria reduces N_2O emission when solid swine manure was composted in a pilot scale forced-aeration (Fukumoto et al., 2006). However, when this was done with solid cattle feedlot manure in open windrow composting, no effect on N_2O emission was observed (Hao et al., 2005).

Emissions may come from the composting process itself and from the equipment used to manage the process. Carbon dioxide released during composting is considered biogenic, so does not count in GHG calculations. While it is theoretically possible for CH_4 to be generated in a poorly managed compost pile, the Environmental Protection Agency (EPA) has concluded that there is little evidence that this actually happens, so considers any releases negligible (EPA, 2002). On the other hand, the fuel and electricity used to operate the equipment and buildings result in anthropogenic releases. Methane is formed as a by-product of microbial respiration in severely anaerobic environments when carbon is the only electron acceptor available. Carbon is used as an electron acceptor when other, more energetically favorable electron acceptors, including oxygen, nitrogen, iron, manganese, and sulfur, have been exhausted. Because the environments in a waste storage lagoon, landfill, or compost pile are not uniform, it is also possible that different electron acceptors can be used simultaneously. For example, when sulfur is used as an electron acceptor, highly odorous compounds, including dimethyl disulfide and methyl mercaptan, are formed. The presence of these compounds can be indicative of the presence of CH_4. A compost or waste pile that exhibits minimal odors is more likely to have aerobic conditions throughout than a malodorous pile of processed feedstocks.

Nitrous oxide is a potent GHG, with the global worming potential of 298 over 100 years (IPCC, 2007). Even though many authors agree that compost management is decisive to determinate the amount of emission (Hao, 2007; Szanto et al., 2007; Hellebrand and Kalk, 2000) there is a difficulty to establish the variables that will be influencing the emissions the most. For instance, during the initial phase of composting oxygen limitation plays a big role (Jarvis et al., 2009). In compost nitrous oxide peaks after 9 and 21 days of composting and are attributed to nitrification and denitrification processes, respectively (Jarvis et al., 2009). During the mesophilic temperature the initial phase of composting is beneficial for nitrous oxide formation and when thermophilic conditions are reached, the production decreases (Beck-Friis et al., 2003). In denitrification process, nitrous oxide is an intermediate product, which can be transformed to N_2 if the N_2O reductase is present in the microbial community and the pH levels are beneficial (pH 6.5 to 7) for its assembly and functioning (Bergaust et al., 2010). A substantial release of N_2O happens after the turning operations due to the transfer of NO_2^-/NO_3^- from aerobic portion into the anoxic portion (Jiang et al., 2011). Higher aeration rates increases the nitrification rate, producing both N_2O and higher concentrations of NO_2^-, NO_3^- in the material. Nitrous oxide in maturation phase of composting can be expected due to both nitrification and denitrification processes, which is especially relevant for larger composts as oxygen gradient is formed within the material (Beck-Friis et al., 2001) temperatures in mesophilic range and natural aeration is reducing. These conditions allow both nitrification and denitrification activities to continue.

Reduction of GHG emission from compost

GHG emissions from the agricultural sector can be reduced through implementation of improved management practices. For example, the choice of manure storage method should be based on environmental decision criteria, as well as production capacity. By composting all the cattle manure stored as slurry and stockpile, a reduction of 0.70 Tg CO_2-e year^{-1} would be achieved. Similarly, by collecting and burning CH_4 emissions from existing slurry facilities, a reduction of 0.76 Tg CO_2-e year^{-1} would be achieved. New CH_4 emission factors were estimated based on these results and incorporated into the IPCC methodology. For North-America under cool conditions, the CH_4 emission factors would be 45 kg CH_4 ha^{-1} year^{-1} for dairy cattle manure rather than 36 kg CH_4 ha^{-1} year^{-1}, and 3 kg CH_4 ha^{-1} year^{-1} for beef cattle manure rather than 1 kg CH_4 ha^{-1} year (Pattey et al., 2005) contribution that manure management makes to total national agricultural emissions of N_2O and CH_4 vary, but can exceed 50% in countries reporting to the UNFCCC in 2009. On farm management decisions interact with environmental controls such as temperature and water availability of key microbial processes (that is, nitrification, denitrification, methanogenesis, CH_4 oxidation), affecting the magnitude of emissions from each stage of the manure management continuum. We review the current understanding of how manure management influences direct and indirect N_2O emissions and CH_4 emissions, introduce new data comparing direct N_2O emissions following spreading of a range of manure types by different methods, and highlight some of the mitigations being considered by researchers and policy makers in developed and developing countries (Chadwick et al., 2011).

GHG emission could be reduced by managing compost pile size as larger piles increase CH_4 and N_2O emissions due to poor aeration (Fukumoto et al., 2003). Forced aeration and turning generally reduces CH_4 emission (Lopez-Real and Baptista, 1996), while increasing compost pile porosity could reduce N_2O emission (Møller et al., 2000). Bedding material used in cattle feedlots not only affects NH_3 emission in the feedlot pen, but also GHG emission during composting. However, in open windrow composting, straw or woodchip bedding made no difference to GHG emissions from cattle feedlot manure (Hao et al., 2004).

The effects of diet manipulation on manure properties can also carryover to affect GHG emission from manure composting. When an 85% barley grain finishing diet was replaced with 60% dried distilled grains (DDGS) and only 25% barley grain, N_2O emissions from composting cattle manure were higher but CH_4 emissions were not affected (Hao et al., 2011). The greater N_2O emission can be attributed to the higher N content in DDGS.

Separation of MSW followed by recycling (for paper, metals, textiles and plastics) and composting/anaerobic digestion (for putrescible wastes) gives the lowest net flux of GHGes, compared to other options for the treatment of municiipal solid waste. In comparison with landfilling untreated waste, composting/anaerobic digestion of putrescible wastes and recycling of paper produce the overall greatest reduction in net flux of greenhouse of gases

BIOCHAR (BC) GHG ACCOUNTING AND EMISSION TRADING

It is possible to combat GHG emissions and reinvigorate rural and agricultural communities simultaneously through the use of BC. BC is the name given to charcoal produced for agronomic and other ecosystem applications (Gaunt and Cowie, 2009). It is produced by heating biomass in the absence of oxygen, a process known as pyrolysis. In addition to stably sequestering the carbon in the BC for periods of time estimated to be several hundred to several thousand years (Lehmann and Joseph, 2009) BC can be applied to cropland to increase crop yields, decrease runoff, decrease fertilizer and lime use, increase soil fertility and minimize nitrous oxide (N_2O) and methane (CH_4) emissions, which are also potent GHGs (Sohi et al., 2009). Stored solid manure heaps can be a significant source of N_2O and CH_4 emissions. The manure characteristics influence emissions and solid manure heaps can be managed to promote aerobic decomposition during storage. Increasing the carbon content of the manure heap with high-C additives, such as straw, may provide the opportunity for N_2O and CH_4 emission reduction (Yamulki, 2006). Adding high-C additives, such as straw could be a promising strategy for reducing GHG emissions because it influences the dry matter content, C:N ratio and aeration of the manure. The small-scale farmyard manure (FYM) storage method were shown to be a reliable and an easy method to quantify emissions under a range of environmental conditions and manure manipulations and so develop effective manure management practices to reduce GHG emissions (Yamulki, 2006). BC has been shown to act as an absorber of NH_3 and water-soluble NH_4^+ and might therefore reduce losses of N during composting of manure (Steiner et al., 2010).

BC's porous structure allows oxygen to move through the material, and maintaining these air passageways enhances microbial activity and provides for a faster and odor-free decomposition. Studies have also shown a significant reduction in N-P-K loss during the decomposition process as nutrients and minerals bond to the BC. In using BC, commercial composters find the reduction in GHG emissions and ability to sell their compost as an enhanced N-P-K fertilizer quite significant.

TURNING, COMPACTING AND THE ADDITION OF WATER TO MINIMIZE GASEOUS EMISSIONS FROM COMPOST

Composting allows simple management of animal manure but excessive aeration can increase emissions of polluting gases such as ammonia or nitrous oxide. In an experiment the effect of three techniques - turning, compacting and the addition of water - on gaseous emissions was studied. One ton of cattle manure and 3 tons of turkey manure were composted in two and four cells for 46 and 51 days, respectively. The manure was either turned, wetted, or compacted. Emissions of carbon dioxide, water vapor, ammonia and nitrous oxide were monitored. The results show that turning did not alter the free air space. Compacting can be used specifically to reduce the water loss. A reduction of free air space by 20 to 60%, either by compacting or adding water (or both), reduced the ammonia and nitrous oxide emissions by 30 to 70% (El Kader et al., 2007).

GHG BALANCE FOR COMPOSTING OPERATIONS

The primary carbon credits associated with composting are through CH_4 avoidance when feedstocks are composted instead of land filled (MSW and biosolids) or lagooned (animal manures). Methane generation potential is given based on total volatile solids, expected volatile solids destruction, and CH_4 generation from lab and field incubations. For example, a facility that composts an equal mixture of manure, newsprint, and food waste could conserve the equivalent of 3.1 Mg CO_2 per 1 dry Mg of feedstocks composted if feedstocks were diverted from anaerobic storage lagoons and landfills with no gas collection mechanisms. The composting process is a source of GHG emissions from the use of electricity and fossil fuels and through GHG emissions during composting. GHG emissions during composting are highest for high-nitrogen materials with high moisture contents. These debits are minimal in comparison to avoidance credits and can be further minimized through the use of higher C:N feedstock mixtures and lower-moisture-content mixtures. Compost end use has the potential to generate carbon credits through avoidance and sequestration of carbon; however, these are highly project specific and need to be quantified on an individual project basis (Brown et al., 2008).

Additional credits could be available from the compost use. 14,800 tons of food scraps might result in 2100 tons of finished compost (wet weight at 30% moisture). According to EPA, 0.05 metric tons of carbon equivalents per wet ton of finished compost are sequestered after 10 years. This would add an additional 105 tons of credit to the methane avoidance credit. The Recycled Organics Unit (ROU) study noted that this is a conservative estimate, as it does not include multiplier effects that might accrue from increased yield due to higher organic matter content. In the life cycle analysis performed by the ROU, the reduction in crop inputs such as fertilizer, herbicides and irrigation water coupled with the carbon sequestration more than made up for the emissions stemming from compost production and production transportation. They concluded that there is a net reduction in global warming potential from the windrow composting of yard debris. This was true even if the compost was transported over 400 miles and the trucks returned empty. As can be seen in this example, the primary benefit of composting from a climate change perspective is in the avoidance of methane generation. Sending organics to an anaerobic digester for methane production and use as energy would likewise avoid the GHG release with the additional benefits of replacing non-renewable energy. Some additional credits may come from the use of compost, via carbon sequestration and via reduction of GHG by displacing other inputs. The specific benefits of any composting venture will have to be figured on a case-by-case basis.

The benefits associated with compost use, in relation to GHG emissions were considered by the USEPA (2002), recycled organics unit (Unit, 2006), and (Smith et al., 2001) in their calculations. The EPA estimate and recycled organics unit based their calculations on specific end-use cases. Smith et al. (2001) based their calculations on more general properties of compost and the potential for compost to replace peat for a range of end uses. For their estimate, the recycled organics unit modeled two types of end use for compost as a soil conditioner for cotton with an application rate of 12 Mg ha^{-1} and as mulch for grapes with an application of 75 Mg ha^{-1} every 3 years.

Factors that were considered included increased soil carbon, reduced water usage, fertilizer value, and reduced use of herbicides. The soil conditioner is a nutrient-rich product with total nitrogen of 1 to 2% and a water-holding capacity of 50 to 60%. It contains 55 to 75% organic matter (Brown et al., 2008). As a soil conditioner, the potential carbon credits or benefits associated with compost use were (a) Increased soil water-holding capacity of 2.4 to 3%, resulting in reduced irrigation of 0.13 to 0.16 ml H_2O ha^{-1} in irrigated cotton (reduced energy requirements for irrigation), (b) Fertilizer equivalent of 34 to 68 kg N, 29 to 57 kg P, and 24 to 48 kg K ha^{-1} for the first year (reduced energy from avoidance of synthetic fertilizers). (c) Sequestering 2.9 to 5.9 Mg C ha^{-1} after 10 years. Mulch is categorized as a low-nutrient mixture made from garden wastes with 75 to 95% organic matter and total nitrogen of 0.2 to 0.4%. The water-holding capacity of the mulch is 10 to 20%. The benefits associated with use of compost and using mulch are multifold. It increases soil water-holding capacity of soils by 9.8%, with total savings of 0.95 ml H_2O ha^{-1} for irrigated viticulture. It replaces herbicide from 2 to 6 L ha^{-1}. It also facilitates carbon sequestration of 11.6 Mg C ha^{-1} after 10 years, a potential opportunity for carbon credit.

CONCLUSION

The carbon farming initiative (CFI) has been introduced in many countries to allow landholders to generate offset credits from activities that reduce emissions or sequester carbon, including BC application. This scheme will provide confidence to those purchasing offsets, and regulate those making claims of “carbon neutrality”. Eligible activities that can earn offset credits include a range of land management, agricultural practices, composting. Under the CFI, building soil carbon, reforestation, and reducing livestock emissions are some of the activities that could generate carbon credits. Application of BC to soil and compost can be listed as an eligible activity. Strategies for offsetting current emissions by carbon sequestration and composting are the only viable way to slow the effects of climate change and provide an additional time frame for the development and implementation of new technologies for an attainable sink of GHG.

Conflict of interests

The author(s) have not declared any conflict of interests

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Scientific Research and Essayss

Full Length Research Paper

Evaluation of the fixed oil of two commonly consumed spices, *Monodora myristica* and *Myristica fragrans*, as adjunct in food formulations

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The seeds of two commonly consumed spices; *Monodora myristica* (Mm) and *Myristica fragrans* (Mf) were separately defatted with n-hexane and the resulting oils were analyzed for their physicochemical properties and fatty acids profile with a view to assessing their nutritional potentials. Results revealed that Mm and Mf had respective percentage oil yields of 25% and 37.7%; free fatty acid of 32.52 and 1.71%; saponification values of 240.95 and 230.47 mgKOH/g; iodine values of 89.75 and 97.75 gI_2/100g oil; peroxide values of 2.32 and 1.65 MeqKOH/g. Oleic acid (36.35%), linoleic acid (50.27%) and linolenic (1.55%) acids were the major unsaturated fatty acids detected in *M. myristica* spice oil while palmitic acid (8.78%) and butyric acid (3.74%) were the few saturated fatty acids contained in the oil. In *Monodora fragran* soil, palmitoleic (1.78%), oleic (14.82%) and linolenic (3.36 %) were the unsaturated fatty acids obtained, while butyric (24.20%), hexanoic (6.74%), lauric (16.71%), myristic (3.40%), palmitic (26.72%) and stearic (2.57%) were the saturated fatty acids detected in the oil. *M. myristica* contained higher proportion of polyunsaturated fatty acids compared to *Monodora fragrans.* The high free fatty acids with low iodine value in Mm and high saturated fatty acids in Mf called for caution in their encapsulation in food formulations.

Key words: *Monodora myristica, Myristica fragrans*, fatty acids profile, food formulations.

INTRODUCTION

In developing countries several plants give edible products, fruits, seeds, leaves, flowers, nuts and oils which take a large place in the local diet and could strongly overcome or ameliorate food and health problems. Some of these edible food parts are used as spices to season foods while most are used as food and drug. The distinction between food and drug is not always clear because most of the edible seeds possess these two properties (Koudou et al., 2007). Typical examples of seeds that possess both characteristics and also serve as spices are *M. myristica* and *Myristica fragrans*.

M. myristica (Annonaceae) commonly known as 'Ariwo' in South Western Nigeria is a tropical tree that grows wild in many African countries including Nigeria (Okafor, 1987; Fournier, 1999). Nutritional values of *M. myristica* center on its usefulness as seasoning because of its

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Table 1. Physicochemical properties of the spice oils.

Property	*Monodora myristica* oil	*Myristica fragrans* oil
Colour	Amber	Light yellow
Oil yield (%)	25.40 ± 0.25	37.72 ± 0.42
Specific gravity	0.8634 ± 0.003	0.634 ± 0.002
Refractive index at 28°C	1.469 ± 0.001	1.686 ± 0.001
Free fatty acid value (%)	32.52 ± 0.20	1.71 ± 0.22
Saponification value (mgKOH/g)	240.95 ± 0.20	230.47 ± 0.25
Iodine value (gI_2/ 100 g)	89.75 ± 0.20	97.75 ± 0.20
Peroxide value (MeqKOH/g)	2.32 ± 0.22	1.65 ± 0.10

Mean ± SD of triplicate determinations.

aromatic flavor. The kernel obtained from the seeds is a popular condiment used as spicing agent in both African and Continental cuisines in Nigeria (Ekeanyanwu et al., 2010). The seeds are aromatic and used as stimulating addition to snuff and medicine (Uwakwe and Nwaoguikpe, 2008). Several of its medicinal uses have been reported; the bark is used in the treatment of stomach-aches, febrile pain, eye diseases and heamorrhoids (Weiss, 2002). In Central African Republic, the seeds are used as condiment and drugs in the treatment of head ache and hypertension (Koudou et al., 2007).

Also, *M. fragrans* Houtt (family: Myristicaceae) is indigenous to the Malay Peninsula and Penang but now cultivated in many tropical countries of both the hemispheres (Evans, 1996). The use of *M. fragrans* as a spice, was introduced into the Europe probably during the twelfth century. *M. fragrans* commonly known as nutmeg has been reported to have aromatic, stimulant, narcotic, carminative, astringent, aphrodisiac, hypolipidemic, antithrombotic, anti-platelet aggregation, antifungal, anti-dysenteric, anti-inflammatory activities (Janssen and Laeckman, 1990). It is used as a remedy for stomach ache, rheumatism and vomiting in pregnancy. The kernel contains volatile oil, a fixed oil, protein, fats, starch and mucilage, and the acetone soluble part of n-hexane extract of *M. fragrans* have been reported to possess anxiogenic, sedative and analgesic activity (Sonavane et al., 2001). However, there is limited information on the physicochemical properties and fatty acids profile of the fixed oils of both spices. In view of this, the present study characterized the spices fixed oils to determine the suitability for encapsulation as food additives.

MATERIALS AND METHODS

M. myristica and *M. fragrans* were purchased at 'Jagun' market, Ogbomoso, Oyo State, South West Nigeria. The seeds were removed from the pod and separated from any dirt. The seeds removed were dried to a constant weight in a Gallen kamp Oven BS Model DV-160 at a temperature of 105°C and milled using a Kenwood blender. The milled samples were then stored in airtight container prior to analyses.

Analysis of extracted oils

The oil exhaustively extracted from the dried samples in a Soxhlet apparatus using n-hexane as the extractant was concentrated by rotary evaporator and all solvent completely expelled. The refractive index of the oils was measured at room temperature using the Abbey refractometer (Prince Optical Works, MalkaGanj Delhi, India). Specific gravity was also determined using a specific gravity bottle (BS 733, Jaytec, Hastings, UK). The oil obtained were analyzed for the acid value, saponification value, free fatty acid, iodine value and peroxide value using standard methods of the American Oil Chemist Society (AOCS, 1973).

Fatty acid composition

A 100 mg oil sample was saponified with 1.2 ml of 0.5 M methanolic KOH at 60°C for 10 min, neutralized with 0.7 M HCl and methylated with 3.0 ml BF_3–CH_3OH for about 10 min in a water bath at 60°C. The product was then extracted with petroleum ether (40 to 60°C). The fatty acid methyl ester was separated by a Perkin Elmer Autosampler XL gas chromatograph with BPX-70.02; 30 m × 0.25 mm (i.d.); 0.25 µm film thickness column. Helium was the carrier gas at a flow rate 20 Psi and a split injector (220°C, split flow rate, 40:1). The temperature was programmed from 60°C at 10°C min^{-1}, then 180°C at 4°C min^{-1} and finally 235°C. The total run time was 27.7 min. Detection was by FID at 220°C. Identification and quantification of the methyl esters was made by comparison of retention times with standard fatty acid methyl esters obtained from Sigma aldrich chemicals.

RESULTS AND DISCUSSION

The physicochemical properties of both spices were reported in Table 1. *M. myristica* oil was amber red colour while *M. fragrans* was light yellow. *M. myristica* spice yielded 25.4% oil while *M. fragrans* yielded 37.7% oil. These values were higher than 18.90% yield in another spice; *Syzygium aromaticum* (Bello and Jimoh, 2012). Both oils have specific gravity less than one indicating that they are less dense than water. This is an advantage since they can act as potential fuel source in biodiesel

Table 2. Fatty acids compositions of *Monodora myristica* (Mm) *and Myristica fragrans* (Mf).

Fatty acids	*Monodora myristica* (%)	*Myristica fragrans* (%)
Butyric	3.74	24.20
Hexanoic	---	6.74
Lauric	---	16.71
Myristic	---	3.40
Palmitic	8.78	26.72
Palmitoleic	---	1.78
Stearic	---	2.57
Oleic	36.65	14.82
Linoleic	50.27	---
Linolenic	1.55	3.36
Total saturated fatty acids	12.52	80.34
Total unsaturated fatty acids	88.47	19.96

production for fuel injector engines which depends on fuel with very low density. The specific gravity of biodiesel ranges between 860 to 900 kg/m^3 at 15°C. Both oils have iodine values of 89.75 and 97.75 g I_2/ 100g oil, which is less than 100, and are comparable to castor seed oil (Akpan et al., 2006). Oils with an iodine value less than 100 is classified as non-drying oils which has a wide variety of industrial uses; thus they are suitable for preparing soaps and cleansers, cosmetics, lubricants, leather dressings and candles. During use, they will not deteriorate to any appreciable extent due to oxidation and polymerization. The spice oils investigated in this study will have a longer shelf life compared to some conventional oils with iodine value above 100, such as corn oil (103 - 128 g I_2/ 100 g oil), cotton seed oil (99 - 119 g I_2/ 100 g oil) which are more suitable for use in the food industries (Noor and Ikram, 2009). The low peroxide values 2.32 and 1.65 MeqKOH/g *M. myristica* and *Myristica fragran s*oils respectively show that the oils could be stable to relative oxidation. The free fatty acid (FFA) is the amount of fatty acid that is not triglycerides; it is an important variable in considering the quality of oil, because the lower the FFA values, the better the quality of oil. The %FFA (32.52) obtained for *M. myristica* in the present study was similar to 34.55% FFA reported by Faleyimu and Oluwalana (2008) in their study. This means there could be higher proportion of other lipid associated substances like sterols, fat soluble vitamins in *M. myristica*. The percentage FFA in *M. fragrans* was however lower (1.71%). The high amount of free fatty acids in the oils is of concern especially when considered as adjunct in food formulations; the oils might be more suitable for industrial applications.

The fatty acids profile obtained (Table 2) showed that the major fatty acids present in *M. myristica* was butyric acid (3.74%), palmitic acid (8.78%), oleic acid (36.65%), linoleicacid (50.27%) and linolenic acid (1.55%). *M. myristica* contains a high percentage of polyunsaturated fatty acids (PUFA) and monoene. Linoleic acid ($C_{18:2}$), is the dominant PUFA (50.27%) in *M. myristica* which compared closely and favourably with linoleic acid content (57.59%) in *Crotalaria cleomifolia* seed oil and sunflower, cottonseed, corn, and sesame seed (Noor and Ikram, 2009). The oil also contain linolenic acid ($C_{18:3}$) and higher level of a monoene, oleic acid ($C_{18:1}$). The proportion of oleic acid (36.65%) and linolenic acid (1.55%) in *M. myristica* oil compared favourably with 38.7% oleic acid in palm oil and higher than 1.0% of linolenic acid in maize oil (Matos et al., 2009). Linoleic and linolenic acids are important essential fatty acids required for growth, physiological functions and maintenance. The oil contain minor amount of saturated acids butyric acid (3.74%) and palmitic acid (8.78%). The total amount of saturated and unsaturated fatty acids in *M. myristica* is 12.52 and 88.47%, respectively. Although, oil with high level of unsaturated fatty acids have been reported to reduce the risk of heart diseases associated with cholesterol (Law, 2000), the high proportion of free fatty acids in the oil might be a disadvantage for its use in food formulations.

Also in Table 2, *M. fragrans* also contain monoenes and PUFA. The unsaturated acids include, oleic ($C_{18:1}$) 14.82%, linolenic ($C_{18:3}$) 3.36% and palmitoleic acid ($C_{16:1}$) 1.78%. The proportion is very low compared to the saturated acids. Major saturated fatty acids present include palmitic acid ($C_{16:0}$) 26.72%, butyric acid ($C_{4:0}$) 24.20%, lauric acid ($C_{12:0}$) 16.71%, hexanoic acid ($C_{6:0}$) 6.74%, myristic acid ($C_{14:0}$) 3.40% and stearic acid ($C_{18:0}$) 2.57%.The total amount of saturated and unsaturated fatty acids in *M. fragrans* is 80.34 and 19.96% respectively. The high proportion of the saturated fatty acids (80.34%) in the oil is also of concern because of the health risk (antherosclerosis or heart disease) associated with oils containing high percentage of saturated fatty acids (Matos et al., 2009). However, it can be suitable for industrial uses such as preparing of soaps and cleansers, cosmetics, lubricants, leather dressings and candles.

Conclusion

The oils from the seeds of *M. myristica* and *M. fragrans* were analyzed for their physicochemical properties and fatty acids profile. The two seeds have demonstrated a good potential as an oil seed with satisfactory percentage oil content. The oils can also be a good source of fuel in biodiesel application based on their relatively low density. The chemical properties of the oils indicated their suitability for several industrial applications because of their ability to withstand degradation due to oxidation. Lastly, the high level of free fatty acids in *M. myristica* (32.52%) and high level of saturated fatty acids in *M. fragrans* (80.34%) called for caution in their incorporation as food additives.

Conflict of interests

The author(s) have not declared any conflict of interests.

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Impact of organic techniques of seed crop management on seed yield and quality in rice cv. ADT 43

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A study was conducted at the Department of Seed Science and Technology, Tamilnadu Agricultural University, Coimbatore in June - July season of two different years to find out suitable organics for enhanced productivity of rice cv ADT 43 for organic seed production. The treatment comprises of soil application of neem cake, biogas slurry, vermicompost, green leaf manure + azolla and farmyard manure based on recommended N requirement and was compared with inorganic fertilization with recommended doses of NPK. At vegetative, flowering and seed maturation stages, parts of the treatments were sprayed with panchagavya 3%, where the unsprayed plots served as check except for plots applied with inorganic nutrients. The results revealed among the organic soil application of neem cake (1786 kg ha^{-1}) along with 3% panchakavya foliar spray maximized the yield along with yield attributing characters (plant height, total number of tillers hill^{-1}, productive tillers hill^{-1}, chlorophyll content, panicle length). However, the yield was higher with basal nutrients applied as inorganic (3537 kg ha^{-1} in initial and 4352 kg ha^{-1} in confirmation), which was on par with neem cake + panchakavya (3500 kg ha^{-1} in initial and 4315 kg ha^{-1} in confirmation),GLM + azolla (3380 kg ha^{-1} in initial) and GLM + azolla + panchakavya (4213 kg ha^{-1} in confirmation) treatments and sprayed with panchakavya at vegetative, flowering and maturity, but both were on par with organic nutrients scored as the best in both years (initial and confirmation) of experimentation and was followed by nutrients applied in the form of neem cake and sprayed with 3% panchakavya spray and was on par. Evaluation of resultant organic seed quality characters including field emergence of organically produced seed as above also recorded higher filled seeds, seed recovery, seed hardness, 100 seed weight, seed germination, vigour, biochemical attributes, such as total sugars and protein content and the activity of ATPase, alpha – amylase and dehydrogenase enzymes ,which were even higher than seeds of inorganic nutrients.

Key words: Rice, organic seed production, organic techniques, organic manures, quality seeds.

INTRODUCTION

Rice (*Oryza sativa* L.) is the important world's staple food, particularly in South Eastern countries; while in India 70% of the population depends on rice for their feeding. During the year 2010 to 2011, rice with 94.01 million tonnes of production contributed to 40.5% of the total food grain production of the country (Anonymous, 2011). Venkataramani (2002) also expressed that Asian people consume 92% of the 90% global rice production.

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India is the largest country with rice cultivated area of 44.97 million hectares and holds the second position in production (85.5 million tonnes) next to China and contributes 7.53% of the world's total rice production.

In India, the green revolution undoubtedly helped to tide over the food crisis during the last four decades. Use of chemical fertilizers is one of the major factors for increasing the food production from 50 million tonnes to 200 million tonnes. The quantum of chemical fertilizer usage has also been increased from 1.54 million tones during 1967-1968 to 26.4 million tonnes in 2009-2010 (Anonymous, 2011). Continuous usage of fertilizers enhanced the demand for fertilizers to the tune of about 28 million tonnes from the current level of 17 million tonnes and pesticides to 1.5 lakh tonnes as against current usage of 0.8 lakh tonnes. But were extremely exploitative and started expressing their ill effects with advances in periods. Inspite increased use of costly inputs, it is not certain whether we could meet the challenge of feeding the people to desired extent with the right quality of safe food. It is now realized that the first green revolution has weekend ecological base in addition to degrading soil, water resources and the quality of the food. At this juncture, a keen awareness has sprung on the adoption of organic farming as a remedy to cure the ills of modern chemical agriculture. Organic agriculture is environmentally friendly ecological production system that promotes and enhances biodiversity, biological cycle and biological activities. It is based on minimal use of off-farm inputs and management practices that restore, maintain and enhance ecological harmony. The principal guidelines for organic production are to use materials and practices that enhance the ecological balance of natural systems and integrate the parts of the farming systems into an ecological holistic system. Organic agriculture practices cannot ensure that products are completely free from residues; however, methods are used to minimize pollution of air, water and soil. The primary goal of organic agriculture is to optimize the health and productivity of interdependent communities of tiring soil, plant, animals and people. Use of organic manures in one form or the other, though inherent in Indian farming has advantages like nutrient conservation, slow release, improvement of soil physical conditions resulting in higher crop yields. For efficient nutrient management in a cropping system basis, the use of available organic resources such as FYM, compost, biogas slurry, green manure, green leaf manure, sewage sludge, urban waste, farm waste and crop residues should necessarily dovetailed for increasing soil productivity. Keeping in view of the nutrient needs of the crop, use of biofertilizers and microorganisms also could be adopted (Krishnappa et al., 1993). Since rice is being cultivated throughout the year, quality seed production plays a vital part to supply seeds in time at reasonable cost. Seed production in rice varieties involves application of large quantities of inorganic inputs in the field as well as on the foliage of the crop to facilitate production of good quality seed. But it may cause some adverse effects on soil and environment. Hence, seed production using organic means is getting momentum nowadays. As per the stipulations of International Federation of Organic Agriculture Movements (IFOAM), sowing organic seed has become mandatory for organic agriculture since 2003. Nutrition to mother crop plays a significant role in improving the yield and quality of seed. Maximum yield is a constantly moving target because of continuing technological advance. Organic nutrient management has more often been used as low and locally available input sustainable agriculture by maintaining soil fertility. The present study was therefore initiated to study the effect of mother crop nutrition in relation to organics and to compare with the inorganic inputs on seed yield and quality in rice cv. ADT 43 in the June – July season of 2003 as initial and 2004 as confirmation trail.

MATERIALS AND METHODS

The experiment was designed in Randomized Block Design with three replications during June – July season for two consecutive years (initial and confirmation). The area were ploughed and puddled well adopting RBD with three replications, the plots of size 3.25 x 3.25 m (net plot size 3 x 3 m) were segregated and the basal application of nutrients in different forms of organic viz; (T_1) Neem cake (1786 kg ha^{-1}), (T_2) Biogas slurry (5555 kg ha^{-1}), T_3 - Vermicompost (3333 kg ha^{-1}), T_4 -GLM (Green Leaf Manure) (3641 kg ha^{-1}) + *Azolla* (1000 kg ha^{-1}), T_5 – FYM (Farm Yard Manure) (12500 kg ha^{-1}) were applied based on the inorganic nitrogen recommended for the crop. Each of the above set of treatment were also sprayed with three per cent panchakavya (T_6 - T_1 + Panchakavya, T_7 -T_2 + Panchakavya, T_8 - T_3 + Panchakavya, T_9 - T_4 + Panchakavya, T_{10} - T_5 + Panchakavya) at vegetative, flowering and seed maturation stages. These organic treatments were also compared with (T_{11}) inorganic nutrient source at 100 : 50 : 50 N P K kg ha^{-1}as per the recommendation of CPG (1999). Twenty-five day old seedlings organically produced seedlings (applied with FYM only) were transplanted after root dipping in 2% *Pseudomonas* and transplanted at the spacing of 15 x 10 cm. During the growth period, based on need the plant protection measures were taken with organic products such as Neem based products (3 ml/lit) (Neem oil) and *Pseudomonas* for plots evaluated for organic farming, while for T_{11}, the inorganic nutrient source monocrotophos (2 ml/lit) was sprayed. The panchakavya stock solution was prepared using 5 kg of Cow dung, 3 L of cow's urine, 2 L of cow's milk, 2 L of cow's curd and 1 L of cow's clarified butter / ghee as per Natarajan (1999) and were diluted to three per cent for the spray. During crop growth, observations on plant and yield attributes like plant height, days to 50% flowering, leaf folder incidence, number of tillers, number of productive tillers, panicle length, chlorophyll (Yoshida et al., 1972), total number of spikelets $panicle^{-1}$, number of filled seeds $panicle^{-1}$, number of ill-filled seeds $panicle^{-1}$, seed yield $plant^{-1}$, seed yield $plot^{-1}$, computed seed yield ha^{-1}. The resultant seeds were also evaluated for seed quality attributes like seed recovery, seed to husk ratio, seed hardness (Viswanathan et al., 1997), 100 seed weight (ISTA, 1999), seed germination (ISTA, 1999), dry matter production (ISTA, 1999) and vigour index (Abdul-Baki and Anderson, 1973). The seeds were also evaluated for field emergence (%) after thirty days of sowing and the seedlings were measured for the vigour parameters such as dry matter production (ISTA, 1999), vigour index (Abdul-Baki and Anderson, 1973). In

Table 1. Effect of organic seed crop management on plant height, Number of tillers, Days to 50 per cent flowering and productive tillers in rice cv. ADT 43.

Treatments	Plant height (cm)		Number of tillers hill $^{-1}$		Days to 50% flowering		Number of productive tillers hill^{-1}	
	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial
T_1-Neem cake	72.5	68.7	8.9	12.7	77	81	11.2	13.3
T_2-Biogas slurry	62.7	62.6	6.7	10.8	78	81	9.0	11.7
T_3-Vermicompost	64.3	66.3	9.3	11.7	81	83	10.7	13.1
T_4-GLM+azolla	71.7	66.5	10.6	12.8	77	81	11.8	13.2
T_5-FYM	66.4	64.1	7.1	11.0	78	81	9.3	12.4
T_6-T_1+ panchakavya	74.5	76.8	10.9	13.7	74	79	12.0	14.2
T_7-T_2+ panchakavya	70.8	66.4	9.0	12.9	78	81	11.3	12.9
T_8-T_3+ panchakavya	66.3	66.4	8.2	12.5	77	79	11.0	12.7
T_9-T_4+ panchakavya	66.7	66.6	9.2	13.5	79	80	11.3	13.7
T_{10}-T_5+ panchakavya	68.2	67.5	8.5	12.3	78	81	10.9	12.7
T_{11}- Inorganic nutrients	72.8	76.9	11.0	13.9	74	79	12.4	14.3
SEd	0.561	0.363	0.561	0.363	1.024	0.570	0.330	0.363
CD (P=0.05)	1.171	0.756	1.171	0.756	2.052	1.190	0.688	0.757

addition, the seed biochemical attributes like total sugars (Hodge and Hofreiter, 1962), protein content (Piper, 1966), ATPase (Unbreit et al., 1964), alpha–amylase (Simpson and Naylor, 1962) and dehydrogenase activity (Kittock and Law, 1968). The data gathered were evaluated for their significant difference at 5% probability as per Panse and Sukhatme (1999).

RESULTS AND DISCUSSION

Plant height referred to as an index of plant growth, was maximum in neem cake + panchakavya during initial trial, while during confirmation trial, inorganic treatment was the best, but was followed by neem cake + panchakavya (Table 1). Natarajan (2002) has also reported that organic manure application enhanced the rice plant growth attributes. Foliar application of panchakavya would have enhanced the absorption of nutrients, thus increasing the plant height (Sebastian, 2005; Srimathi et al., 2013). Early flowering was noticed in plots applied with neem cake + panchakavya which were on par with the recommended practice of inorganic treatment (Table 1) in both the trials. Early flowering might also be due to early accomplishment of initial stages and correspondingly all other stages of growth, owing to the cumulative effect of both soil and foliar nutrition and also presence of GA and other growth promoting substances in panchakavya (Saritha et al., 2013). Similar advancement of flowering by organic manure + panchakavya in green gram, maize and sunflower were reported by Somasundram (2003) and Shakuntala et al. (2012) in rice.

Total number of tillers varied significantly in all stages (vegetative, flowering and maturity) on account of treatments. Inorganic plots registered the maximum number of tillers and productive tillers which was on par with neem cake + panchakavya (Table 1). Increase in plant height and number of tillers was mainly due to N as reported by De Datta (1981) and in addition to involvement of certain growth substances like IAA (Sen and Bose, 1959). Applications of organic in combination with inorganic fertilizers or biofertilizers or micronutrients have recorded the more number of productive tillers in rice as reported by Hattb (1995). Inorganic treatment and neem cake + panchakavya were again on par in registering maximum panicle length (Table 2). Panicle length even though controlled partly by genetic character was influenced by nutrition as reported by Matsushima (1980).

The other yield components like total number of spikelets panicle^{-1}, filled seeds panicle^{-1} were the highest in neem cake + panchakavya (Table 2) because of balanced supply of nutrients throughout the growth period and proper physiological partitioning from source to sink. By virtue of the ability to provide the nutrients in a steady manner, organics would have increased the filled seeds as compared to inorganic treatment. The maximum chlorophyll content was recorded in inorganic treatment (Table 3).

Chlorophyll is important nitrogen containing compound of the green plants (Mishra and Srivastava, 1983). Neem cake + panchakavya also showed beneficial effect in chlorophyll, which was on par with inorganic fertilizers. The seed yield plant^{-1}, seed yield plot^{-1} and computed seed yield were maximum in inorganic plot (3537 kg ha^{-1} in initial trail and 4352 kg ha^{-1} in confirmation trail), which was on par with neem cake + panchakavya (3500 kg ha^{-1} in initial trail and 4315 kg ha^{-1} in confirmation trail), GLM + azolla (3380 kg ha^{-1} in initial trail) and GLM + azolla + panchakavya (4213 kg ha^{-1} in confirmation trail) treatments (Table 3). The yield level attained in inorganic

Table 2. Effect of organic seed crop management on panicle length, total number of spikelets panicle^{-1} filled and ill filled seeds panicle^{-1} in rice cv. ADT 43.

Treatments	Panicle length (cm)		Total number of spikelets panicle $^{-1}$		Filled seeds (%) panicle $^{-1}$		Ill filled seeds (%) panicle $^{-1}$	
	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial
T_1-Neem cake	18.3	19.5	115	123	81.4	87.0	18.6	13.0
T_2-Biogas slurry	16.4	19.5	95	117	76.8	85.3	23.2	14.7
T_3-Vermicompost	18.4	18.2	115	95	74.7	86.3	25.3	13.7
T_4-GLM+azolla	19.0	19.7	116	118	82.0	85.0	18.0	15.0
T_5-FYM	17.8	19.2	94	106	82.5	86.0	17.5	14.0
T_6-T_1+ panchakavya	19.0	21.0	126	135	85.5	89.3	14.5	10.7
T_7-T_2+ panchakavya	18.3	19.4	104	116	78.9	83.7	21.1	16.3
T_8-T_3+ panchakavya	18.3	19.2	106	126	84.4	83.0	15.6	17.0
T_9-T_4+ panchakavya	18.1	20.9	105	112	81.6	89.2	18.7	10.8
T_{10}-T_5+ panchakavya	18.4	19.2	104	111	80.6	85.0	19.4	15.0
T_{11}- Inorganic nutrients	19.5	21.6	119	129	80.3	78.0	20.2	22.0
SEd	0.329	0.342	2.230	4.577	1.267	1.804	0.676	0.943
CD (P=0.05)	0.686	0.712	4.623	9.492	2.628	3.740	1.402	1.955

Table 3. Effect of organic seed crop management on Chlorophyll total (mg g^{-1}) and seed yield in rice cv. ADT 43.

Treatments	Chlorophyll total (mg g^{-1})		Seed yield plant $^{-1}$ (g)		Seed yield plot^{-1} (kg)		Seed yield ha^{-1} (kg)	
	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial
T_1-Neem cake	2.955	3.347	2.40	4.88	2.90	3.33	3222	3704
T_2-Biogas slurry	2.843	3.250	1.91	4.15	2.63	2.99	2917	3319
T_3-Vermicompost	2.627	2.873	1.88	3.61	2.55	2.81	2833	3120
T_4-GLM+azolla	2.953	3.237	2.67	4.47	3.04	3.35	3380	3722
T_5-FYM	2.633	2.817	2.08	3.99	2.75	2.99	3056	3319
T_6-T_1+ panchakavya	3.116	3.790	2.70	5.33	3.15	3.88	3500	4315
T_7-T_2+ panchakavya	2.975	3.062	2.22	4.55	2.80	3.80	3111	3556
T_8-T_3+ panchakavya	2.976	3.073	2.09	4.39	2.81	3.18	3120	3537
T_9-T_4+ panchakavya	2.927	3.563	2.30	5.26	2.95	3.79	3278	4213
T_{10}-T_5+ panchakavya	3.080	3.110	2.15	5.05	2.84	3.12	3157	3463
T_{11}- Inorganic nutrients	3.195	3.807	2.81	5.81	3.18	3.92	3537	4352
SEd	0.079	0.073	0.093	0.269	0.074	0.104	123.017	115.017
CD (P=0.05)	0.163	0.151	0.193	0.562	0.154	0.216	256.610	239.922

might be due to the immediate availability of nutrients to the plants. Quantity of organics was calculated on equal nitrogen basis. However, inorganic plot received P and K at a dose of 50 kg each per hectare respectively. Organics might not be in a position to make available this much quantity of P and K to the plants. However, some of the organically treated plots also performed on par with inorganic treatment due to other bioactive compounds available in organics. Application of neem cake + panchakavya, GLM + azolla and GLM + azolla + panchakavya evoked response to a greater level as that of inorganic fertilizer application.

Organic matter increased the availability of unavailable plant nutrients by enhancing the biochemical activity of soil microorganisms. Koyama (1975) opined that even under heavy nitrogen application, about 68% of N absorbed by rice was from soil N and humus is an important source of N in soil. The organic source of the treatment might have improved the availability of micronutrients well by binding and protecting them from losses. The bound nutrients will be released for assimilation by plants. Beneficial effects of panchakavya on yield have been reported by Sridhar et al. (2001) in rice, Somasundaram (2003) in maize, green gram and sunflower, Kumaravelu and Kadamban (2009) in greengram and Padmapriya et al. (2010) in *Gymnema sylvestre.* It is also supported by the presence of low leaf folder incidence in neem cake + panchakavya applied

Table 4. Effect of organic seed crop management on Leaf folder incidence (%), Seed recovery (%),Seed to husk ratio and Seed hardness (kg) in rice cv. ADT 43.

Treatments	Leaf folder incidence (%)		Seed recovery (%)		Seed to husk ratio		Seed hardness (kg)	
	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial
T_1-Neem cake	19	10	97.5	95.3	4.29	4.31	13.56	12.85
T_2-Biogas slurry	22	14	96.3	95.9	3.93	4.24	12.66	11.93
T_3-Vermicompost	23	18	97.4	96.8	3.88	4.19	15.45	14.25
T_4-GLM+azolla	20	15	97.5	95.4	4.12	4.29	13.76	12.63
T_5-FYM	22	16	97.3	95.5	3.99	4.22	12.73	11.99
T_6-T_1+ panchakavya	14	9	98.1	97.0	4.32	4.49	15.65	14.37
T_7-T_2+ panchakavya	16	15	97.6	95.6	4.10	4.24	15.62	14.12
T_8-T_3+ panchakavya	17	15	97.1	95.2	4.06	4.23	13.77	12.99
T_9-T_4+ panchakavya	18	13	97.9	96.8	4.11	4.34	14.84	14.00
T_{10}-T_5+ panchakavya	20	13	97.8	95.8	4.07	4.35	14.12	13.32
T_{11}- Inorganic nutrients	30	22	97.3	93.8	3.93	4.24	13.74	12.97
SEd	1.530	1.362	0.384	0.452	0.053	0.019	0.309	0.283
CD (P=0.05)	3.191	2.841	0.796	0.936	0.109	0.039	0.642	0.590

Table 5. Effect of organic seed crop management on 100 seed weight (g), germination, dry matter production (g 10 seedlings^{-1}) and Vigour index in rice cv. ADT 43.

Treatments	100 seed weight (g)		Germination (%)		Dry matter production (g 10 seedlings $^{-1}$)		Vigour index	
	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial
T_1-Neem cake	1.51	1.53	93 (74.66)	95 (77.08)	0.105	0.112	2953	3088
T_2-Biogas slurry	1.45	1.52	92 (73.57)	93 (74.66)	0.102	0.108	2767	2967
T_3-Vermicompost	1.49	1.52	92 (73.57)	90 (71.57)	0.103	0.100	2809	2847
T_4-GLM+azolla	1.50	1.53	94 (75.82)	95 (77.08)	0.107	0.106	2992	3058
T_5-FYM	1.48	1.51	90 (71.57)	89 (70.63)	0.102	0.108	2822	2813
T_6-T_1+ panchakavya	1.52	1.55	95 (77.08)	98 (81.87)	0.110	0.117	3132	3249
T_7-T_2+ panchakavya	1.50	1.53	93 (74.66)	93 (74.66)	0.105	0.111	3168	3032
T_8-T_3+ panchakavya	1.50	1.55	93 (74.66)	93 (74.66)	0.107	0.106	3055	3008
T_9-T_4+ panchakavya	1.50	1.52	92 (73.57)	95 (77.08)	0.107	0.108	3015	3128
T_{10}-T_5+ panchakavya	1.49	1.53	95 (77.08)	98 (81.87)	0.106	0.109	3052	3177
T_{11}- Inorganic nutrients	1.49	1.49	90 (71.57)	89 (70.63)	0.107	0.106	2892	2845
SEd	0.009	0.007	0.678	1.885	0.001	0.002	26.433	54.063
CD (P=0.05)	0.019	0.015	1.407	3.932	0.002	0.004	54.819	112.121

Figures in parentheses indicate arcsine values.

plot and it was higher in inorganic nutrients (30% in initial trail and 22% in confirmation trail) (Table 4).

Seed quality attributes viz., seed to husk ratio, seed hardness and 100 seed weight of size graded seeds (1.5 mm x 19 mm slotted hole sieve) were significantly influenced by organic manures. Percentage recovery of seeds upon grading with 1.5 mm x 19 mm slotted hole sieve were higher in most of the organic treatments (Table 4). Higher seed hardness, Seed to husk ratio and 100 seed weight were maximum in neem cake + panchakavya (Tables 4 and 5). In general, seeds harvested from organic plots recorded higher hardness than inorganic plot (Table 4). This might probably be due to availability of additional growth promoting substances in the organics in addition to major nutrients. Another reason could be that the ready availability would have enabled the plant to absorb more nitrogen resulting in increased succulence of cell wall causing reduced hardness in the seeds of inorganic plots. Chandgiram and Choudhury, (1987) reported that the highest seed hardness in wheat was recorded in control treatment (unfertilized plot). Similar effect of organic on 1000 seed

Table 6. Effect of organic seed crop management on field emergence (%), dry matter production (g 10 seedlings^{-1}), Vigour index and Total sugar (µg g^{-1}) in rice cv. ADT 43.

Treatments	Field emergence (%)		DMP (g 10 seedlings $^{-1}$)		Vigour index		Total sugar (µg g^{-1})	
	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial
T_1-Neem cake	74 (59.34)	75 (60.00)	0.425	0.503	1757	1838	75.95	77.94
T_2-Biogas slurry	65 (53.75)	63 (52.54)	0.480	0.543	1675	1447	73.02	75.29
T_3-Vermicompost	74 (59.34)	69 (56.17)	0.314	0.434	1573	1348	73.23	74.88
T_4-GLM +azolla	77 (61.34)	78 (62.03)	0.328	0.631	1755	1624	74.94	78.01
T_5-FYM	75 (60.00)	74 (59.34)	0.422	0.652	1798	1474	73.53	75.35
T_6-T_1 + panchakavya	88 (69.73)	87 (68.87)	0.682	0.787	2503	2262	77.57	80.63
T_7-T_2 + panchakavya	75 (60.00)	75 (60.00)	0.530	0.659	1992	1403	75.53	77.36
T_8-T_3 + panchakavya	73 (58.69)	72 (58.05)	0.523	0.542	1701	1697	74.94	77.57
T_9-T_4 + panchakavya	80 (63.43)	76 (60.67)	0.518	0.553	1982	1760	77.27	79.62
T_{10}-T_5 + panchakavya	81 (64.16)	77 (60.67)	0.495	0.537	1914	1794	76.96	78.69
T_{11}-Inorganic nutrients	64 (53.13)	62 (51.94)	0.579	0.684	1640	1643	74.34	76.97
SEd	2.258	0.967	0.012	0.006	13.493	49.166	0.523	0.625
CD (P=0.05)	4.684	2.017	0.026	0.012	28.146	102.560	1.088	1.296

Figures in parentheses indicate arcsine values.

weight was reported by Kenchaiah (1997) in rice.

In any seed production activity, achieving high level of germination is the prime objective. As per minimum seed certification standards, rice seeds should posses at least 80% germination. In this study, not only organically produced seed but also seed produced from inorganic treatment registered a germination level of above 80%. However, inorganic seeds had 5 and 8% lesser germination during initial and confirmation trail, respectively than the best organic combination of neem cake + panchakavya (Table 5). Better germination of seeds of the neem cake + panchakavya treatment might be because of increased fillness as revealed from seed to husk ratio and 100 seed weight. Biochemical estimations involving protein content, ATPase activity, alpha-amylase, total sugars and dehydrogenase showed the superiority of neem cake + panchakavya treatment, which again would have been the reason for higher germination (Krishnasamy and Seshu, 1990).

Seed quality, apart from genetic and physical purity, includes viability, health, structural soundness, size and vigour, all of which may influence the performance of a seed (Perry, 1972). Seedling vigour measured through dry matter production and vigour index was maximum in neem cake + panchakavya (Table 5). This again would have been the result and effect of higher seed weight, protein content and enzyme activity present in this treatment. Field emergence is the ultimate measure of seed vigour (Tonkin, 1969). The superior quality seeds produced in neem cake + panchakavya conformed with higher field emergence per cent, dry matter and vigour index in the field emergence test (Table 6). The reason for the favourable effect of neem cake + panchakavya might be due to higher 100 seed weight and better biochemical attributes.

The biochemical attributes like total sugar, protein, ATPase and alpha-amylase activity were higher in neem cake + panchakavya (Tables 6 and 7). Kenchaiah (1997) reported improvement of protein due to neem cake application in rice. Increase in protein content due to panchakavya spray was reported by Somasundaram (2003) in maize, green gram and sunflower and Sebastian (2005) in sunflower. Dutta (1979) had amply demonstrated in rice, the positive association of viability and vigour with dehydrogenase activity. The dehydrogenase activity significantly differed among treatments wherein neem cake + panchakavya registered maximum activity.

Conclusion

Based on this experiment it is observed that there is no much significant difference between inorganic and neem cake + panchakavya 3% spray treatment. But seed quality parameters viz., seed germination, seed filling and field emergence was significantly maximum in organic treatment than inorganic treatment. In addition to the above, the neem cake + panchakavya treatment would not cause any problem to the soil, water and to the rice consumer. Because of this property and for sustaining the paddy seed production, neem cake and panchakavya treatment is the best when compared to the rest of the treatments.

Conflict of Interests

The author(s) have not declared any conflict of interests.

Table 7. Effect of organic seed crop management on seed protein content, ATPase activity (μ mol pi $g^{-1}h^{-1}$), Alpha - amylase activity (cm) and dehydrogenase activity (OD) in rice cv. ADT 43.

Treatments	Protein content (%)		ATPase activity (μ mol pi $g^{-1}h^{-1}$)		Alpha - amylase activity (cm)		Dehydrogenase activity (OD)	
	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial	Initial trial	Conformation trial
T_1-Neem cake	8.72	8.22	0.833	0.647	0.83	1.03	0.128	0.175
T_2-Biogas slurry	8.30	8.02	0.800	0.673	0.75	0.85	0.129	0.181
T_3-Vermicompost	8.61	8.00	0.817	0.527	0.59	0.82	0.128	0.163
T_4-GLM+azolla	8.70	8.30	0.853	0.680	1.03	1.07	0.128	0.182
T_5-FYM	8.68	8.04	0.833	0.467	0.80	0.95	0.120	0.145
T_6-T_1+ panchakavya	8.91	8.52	0.887	0.760	1.05	1.26	0.139	0.197
T_7-T_2+ panchakavya	8.56	8.17	0.823	0.660	0.69	1.05	0.127	0.176
T_8-T_3+ panchakavya	8.71	8.21	0.827	0.537	0.78	1.08	0.138	0.165
T_9-T_4+ panchakavya	8.92	8.24	0.800	0.630	0.76	1.13	0.128	0.166
T_{10}-T_5+ panchakavya	8.82	8.22	0.870	0.770	0.70	1.14	0.128	0.204
T_{11}- Inorganic nutrients	8.51	8.33	0.817	0.693	0.90	1.06	0.130	0.179
SEd	0.079	0.034	0.019	0.031	0.035	0.051	0.002	0.006
CD (P=0.05)	0.163	0.070	0.040	0.063	0.072	0.105	0.004	0.013

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Full Length Research Paper

Estimation of domain name system (DNS) server load distribution

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Domain name system (DNS) resolution service is usually provisioned by multiple authoritative servers for performance and robustness. Estimating the query load distribution among multiple authoritative servers is one of the key issues arising with DNS server load balancing and optimization. We propose an analytical model of Round-Trip-Time (RTT)-sensitive server selections consisting of cache servers, authoritative servers and clients, which makes it possible to infer DNS server load accurately. A DNS server fingerprint approach is then proposed to identify RTT-sensitive server selections from BIND's. Finally, we present a server load estimation method based on server selection classification. Under BIND server selection algorithm, the solution of the server selection model is obtained using iteration method, which is validated by the simulation results.

Key words: Round-Trip-Time, domain name system (DNS) server fingerprint, server selection, load distribution estimation.

INTRODUCTION

The domain name system (DNS) is one of the most fundamental components of the today's Internet, providing a critical link between human users and Internet locations by mapping host names to IP addresses. To enhance the resilience, reliability and scalability of DNS authoritative service, the DNS authoritative data is usually stored at multiple geographically distant servers. Each authoritative server maintains the same DNS zone data. Requests by clients are first served by their cache servers, which then forward the cache missed requests to one of these authoritative servers.

For each emitting query, the cache server decides which authoritative server is the destination per its server selection algorithm. As the DNS specifications (Mockapetris, 1987) are vague on server selection algorithms, current cache server implementations show different effects in their query distribution among a set of authority servers. BIND is by far the most popular cache server implementation in use. It adopts a Round-Trip-Time (RTT) proportional server selection algorithm favoring the small-latent servers. But most of the alternative implementations exhibits sub-optimal server selection behavior, distributing queries evenly among all authoritative servers.

Given potential DNS request volume and distribution from cache servers, the planning and design of the

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number, location, capacity of DNS authoritative servers largely depends on their projected server load distribution. Server load distribution estimation may at least help to achieve a balanced utilization among DNS authoritative servers, preventing the occurrence of such a situation where some servers are overloaded or even overwhelmed while some are underloaded. In case that a particular server is regarded as overloaded and a new server is expected to be added to share its excessive traffic, server load distribution estimation can play a critical role in optimally locating the new server and evaluating its effects of load rebalance. We can also consider the importance of server load distribution estimation when predicting the impacts of DoS/DDoS attacks towards DNS servers. Server load distribution estimation makes it possible to predict precisely how a particular server is flooded by an attack launched from a set of particular cache servers.

This paper provides a server load estimation method based on server selection classification: for RTT-sensitive server selections, an analytical model is proposed; for RTT-sensitive server selections, a DNS server fingerprint approach is proposed to identify them.

RELATED WORK

Many previous efforts on server load estimation were focused on web servers or web services (Zhichun et al., 2010; Vercauteren et al., 2007; Jiani and Laxmi, 2006). While web servers or web services are characterized by handling users' requests for interdependent and dynamic content, communication between cache servers and authoritative servers can be seen as consisting of simple and short queries, therefore DNS server selection plays a more important role in server load estimation.

Previous studies on DNS server selection are limited. Zheng et al. (2010) provided the analytical performance evaluation of BIND DNS selection algorithm. The results are the component basis of this paper. Yingdi et al. (2012) conducted a series of trace-driven measurements to understand the server selection performance of current cache server implementations. The results validate that BIND implements a RTT-proportional server selection algorithm. Supratim et al. (2008) proposed a server selection algorithm using auto-regression models for estimating the server response times. The accuracy of SRTT estimation can be improved by the techniques. Ager et al. (2010) provided measurement study on the responsiveness of DNS in two aspects (1) the latency between clients and DNS cache servers, (2) the content of the DNS cache when the query is issued.

The major security concerns about DNS are the ever-lasting threats imposed by Denial of Service (DoS) attacks. Marios et al. (2013) examined a DNSSEC-powered amplification attack feathered by independence of botnet and undisclosed attackers. However, the impacts of such amplification attack bear little direct relation to server load distribution because the amplified flooding responses from multiple servers are virtually aggregated by cache servers before being forwarded towards victim end users. A robust counter measure against this type of threats is proposed based on Bloom filters (Sebastiano and Dario, 2011). It is deployed at the side of victim end users, thus irrelevant to cache server's and authoritative server's behavior.

The DNS system are extensively measured and examined in recent years. Kyle et al. (2013) presented methodologies for efficiently discovering the complex client-side DNS infrastructure. Craig and Andrew (2013) examined DNS resolver behavior and usage, from query patterns and reactions to nonstandard responses to passive association techniques to pair resolvers with their client hosts. Hongyu et al. (2013) provided some new findings in DNS traffic patterns and proposed a novel approach that detects malicious domain groups using temporal correlation in DNS queries. Thomas et al. (2013) passively monitored DNS and related traffic within a residential network in an effort to understand server behavior--as viewed through DNS responses, and client behavior--as viewed through both DNS requests and traffic that follow DNS responses.

Analytical model of RTT-sensitive server selections

We consider a network consisting of M local DNS cache servers (or server selection nodes) and N distributed authoritative servers. Each cache server j receives DNS requests generated by its clients and if not hit in the cache forwards them to the authoritative servers. Inspired by Jaeyeon et al. (2003) we assume that the requests sent by each cache server j follow a Poisson process with rate λj. It is a simplifying assumption about the inter-arrival times of requests and facilitates our analysis without much loss of generality. The Poisson arrival assumption is also theoretically justified by the fact that it represents the aggregation of requests made by a large population of clients (Karlin and Taylor, 1975). Measurements of request arrivals have been shown to match well a Poisson process, at least over small to moderate timescales (Villela et al., 2007). Each cache server j assigns requests to server i with proportion p_{ji}, independent of other requests, therefore the arrival process to each authoritative server i, i = 1,2,…,N is an independent Poisson process with rate $p_{ji}\lambda_j$. Figure 1 shows the scenario.

We assume that the service time distribution at each server i is arbitrary with mean $\bar{x}_i$. The mean service rate of server i is $\mu_i = 1 / \bar{x}_i$. We assume that each server implements a Processor Sharing (PS) scheduling policy, where all the requests share the server's capacity equally and continuously (Kleinrock, 1976). Under the above

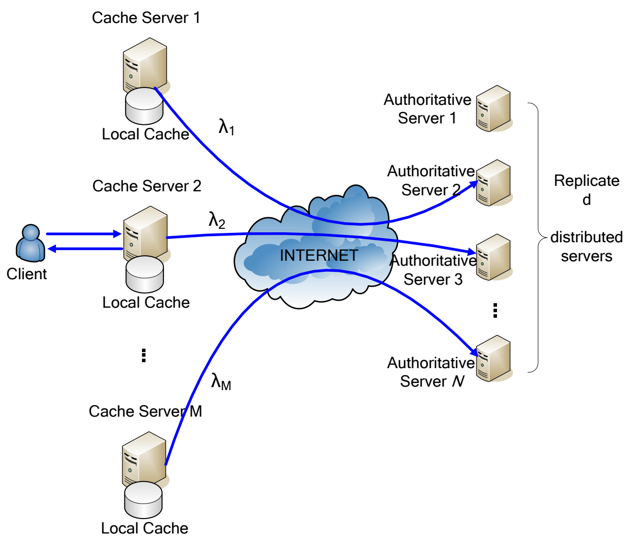

Figure 1. RTT-sensitive server selection model.

assumptions, each server behaves as an-PS queue. Let $\mathbf{P}_i = (p_{1i}, p_{2i}, ..., p_{Mi})'$ denote the server selection proportion vector for authoritative server *i* and $\boldsymbol{\lambda} = (\lambda_{1i}, \lambda_{2i}, ..., \lambda_{Mi})'$ the requests rate vector of the cache servers. Then for a given $\mathbf{P}_i$ in such a network, the average delay of a request forwarded to server is given by the following expression (Kleinrock, 1976):

$$\bar{T}_i(\mathbf{P}_i) = \frac{1}{\mu_i - \sum_{j=1}^{M} p_{ji}\lambda_j}$$

$$= \frac{1}{\mu_i - \mathbf{P}_i'\boldsymbol{\lambda}} \quad (1)$$

Query delay can be approximated as the sum of network latency (largely dependent of network topology) and processing delay (related to the ratio of the name resolution service capability of the authoritative servers to the query arrival rate). So the overall query delay between the cache sever server *j* and the authoritative server *i* is:

$$rtt'_{ji} = rtt_{ji} + \bar{T}_i(\mathbf{P}_i) \quad i = 1,2,...N \quad j = 1,2,...M \quad (2)$$

Where rtt_{ji} is the network latency. Thus rtt'_{ji} is the function of $\mathbf{P}_i$, or

$$rtt'_{ji} = rtt'_{ji}\left(\bar{T}_i(P_i)\right) = rtt'_{ji}(P_i) \quad i = 1,2,...N \quad j = 1,2,...M \quad (3)$$

To minimize the delays experienced by users, RTT-sensitive server selection algorithm (e.g., BIND) prefers the least-latent authoritative server (for good response time) yet still queries the others (to distribute the load and monitor their performance). Latencies between the cache server and the set of authoritative servers are the only metric on which RTT-sensitive algorithm is based. Therefore, query latency impacts significantly on DNS server load distribution. So the server selection proportion is a function of the overall request delay rtt'_{ji}, $i = 1,2,...N$, $j = 1,2,...M$. Consider an element p_{ji} of $\mathbf{P}_i$, $i = 1,2,...N$, $j = 1,2,...M$, it is dependent of the overall delay from the cache sever server *j* to each authoritative server. Therefore each $\mathbf{P}_i$, $i = 1,2,...N$ is decided by total space of overall delay, or

$$\mathbf{P}_i = \mathbf{P}_i\left(rtt'_{ij}, i = 1,2,...N, j = 1,2,...M\right) \quad i = 1,2,...N \quad (4)$$

Equations (3) and (4) indicate the interrelation among the overall delay and the server selection proportion. Although it is possible to express Equations (3) and (4) in the definite form, which actually establishes equation set, we still find it hard to provide a closed-form expression for the solution. We also note that cache server *j*, $j = 1,2,...M$ has no information other than its overall delay rtt'_{ji}, $i = 1,2,...N$. So its server selection reaction is only based on its own overall delay sector but not the total space of overall delay.

Fingerprint RTT-Insensitive server selections

While BIND is by far the most widely used DNS cache server implementations accounting for 53.9% of the total (Infoblox, 2010), there are still other implementations in use. The most popular implementations other than BIND include DNS Cache, Unbound, and Windows DNS. Unlike BIND which shows kind of RTT-proportional server selection, such implementations are RTT-insensitive. This means queries are distributed evenly among all the authority servers. Such sub-optimal server selection makes the problem of sever load estimation simpler, because load distribution is predetermined irrespective of query processing delay affected by load distribution. As RTT-insensitive implementations behave quite differently from BIND and so do their server load distributions, the overall estimation accuracy may be significantly degraded by neglecting RTT-insensitive sever selection or regarding all as BIND's RTT-sensitive. So a key problem arises on how to fingerprint RTT-insensitive server selections and effectively identify them from BIND's counterparts.

A DNS fingerprinting tool is available on (fpdns. https://github.com/kirei/fpdns), which is very accurate and

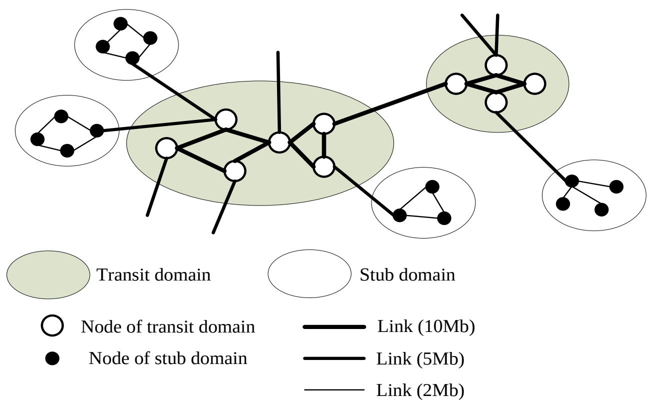

Figure 2. Illustration of network topology.

covers a wide range of DNS implementation types and versions. Its methodology used to identify individual name server implementations is based on "borderline" protocol behaviour. DNS implementations adhere to the well documented standard protocol behaviour in the case of 'common' dns messages, but the DNS protocol also offers a multitude of message bits, response types, opcodes, classes, query types and label types in a fashion that may diversify implementations. The tool uses series of "borderline" query-response messages to identify implementations.

ESTIMATION METHODS

To estimate load distribution, the first step is to identify cache resolvers implementing RTT-insensitive server selection from those implementing BIND's server selection. In this step, a DNS fingerprinting tool may be used to actively probe all cache resolvers that are expected to query the investigated servers. The perceived implementations other than BIND is classified as the RTT-insensitive server selection originators. We then estimate server loads under BIND and RTT-insensitive selection respectively.

For the BIND-based server load estimation, we must integrate BIND server selection algorithm to solve the simultaneous equations consisting of Equations (1), (2) and (4). BIND name servers use RTT to choose between name servers authoritative for the same zone. Each time a BIND name server sends a query to a remote name server, it starts an internal stopwatch. When it receives a response, it stops the stopwatch and makes a note of how long that remote name server took to respond. When the name server must choose which of a group of authoritative name servers to query, it simply chooses the one with the lowest RTT. Before a BIND name server has queried a name server, it gives it a random RTT value, but lower than any real-world RTT. This ensures that the BIND name server queries all of the name servers authoritative for a given zone in a random order before playing favorites. On the whole, this simple but elegant algorithm allows BIND name servers to "lock on" to the closest name servers quickly and without the overhead of an out-of-band mechanism to measure performance. For server S_1, S_2, …, S_n with their RTTs as $rtt_1, rtt_2, \ldots, rtt_n$ respectively, under BIND server selection algorithm, Equation (4) can be instantiated as

$$1 : \log \frac{rtt_1}{rtt_1 * \alpha + rtt_i * (1-\alpha)} / \log \beta : ,..., : \log \frac{rtt_1}{rtt_1 * \alpha + rtt_n * (1-\alpha)} / \log \beta \quad (5)$$

The estimated server load distribution under BIND server selection algorithm can be computed by solving simultaneous equations consisting of Equations (1), (2) and (5). For the RTT-insensitive server load estimation, each cache server j assigns requests to server i always with an equal proportion

$$P_{ji} = 1/N \quad (6)$$

Finally, we can get the overall server load distribution by adding together the BIND-based server load estimation and the RTT-insensitive server load estimation.

Simulations

As RTT-insensitive server load estimation is simple and easy to implement, we only conduct simulations using the BIND server selection algorithm and PS scheduling policy to illustrate the model in this area. To solve the seemingly complicated nonlinear equations, we propose an iteration method to obtain the solution. At the start of iteration, we assume that where the processing delay of the authoritative servers is negligible compared to the network path delay (or in an idle state). So the initial query load distribution can be obtained per Equation (5) given all cache servers' query rates and distances from each authoritative server. Then for the next iteration, each authoritative server's processing delay is taken as calculated in the previous iteration. The query load distribution is updated based on the authoritative server's processing delay and the network path delay between cache servers and authoritative servers. Repeat the process for more iterations until the query load distribution's change is negligible and the server selection reaches a steady state.

We implement the server algorithm in the NS2 simulator. The network topology is generated by GT-ITM Topology Generator provide by NS2. The topology parameters are given as the following (Figure 2): three-level hierarchy: transit domain, stub domain and nodes; 2 transit domains; each transit domain has (on average) five nodes; each transit node connects (on average) to five stub domain; each stub domain has (on average) twenty nodes; each cache server coverage is 10% of the nodes except the 10 transit nodes. We generate

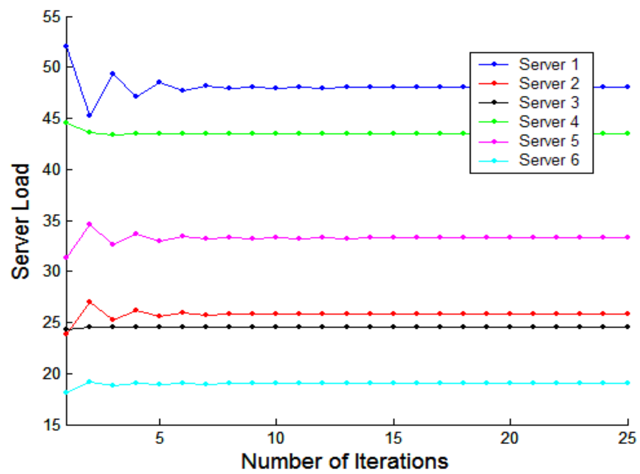

Figure 3. Solving BIND server selection model by iteration.

200 nodes, randomly select 6 nodes as the authoritative servers and the remaining nodes as cache server (Figure 3).

We apply a patch for NS2 (Kostas, 2004) as Poisson traffic generator for cache servers. All cache servers follow the same traffic pattern. The mean packet inter-generation time is set as 1.15 ms, and the size of the packet generated is 256 bytes. Cache servers distribute their queries among all authoritative servers per BIND server selection algorithm. The network latency between each pair of cache server and authoritative server is solely dependent of the network distance in the generated topology. In our simulation, it ranges from 30 to 200 ms. The DNS resolution processing at each authoritative server implements PS scheduling policy and the mean service rate is set as 100 kqps. Once the incoming query rate is aggregated from all cache servers, the query processing delay at an authoritative server is computed and set per PS scheduling policy. Then cache servers may adjust its query load distribution according to the updated RTTs. In response to the updated query load distribution from cache servers, authoritative servers then renew their query processing delays. So the RTTs change accordingly, and so on. The simulation lasts for enough time until we see the dynamic converges to a stable state. The result of iterations is shown in Figure 3. We can see that the query load distribution for each authoritative server quickly converges to a steady value. To see whether the iteration like simulation does find the correct solution formulated in Equations (1) to (5). We plug the convergence values in Figure 3 obtained by simulation into Equations (1) to (5). Their consistency with Equations (1) to (5) shows their correctness.

Conclusions

Estimating the query load distribution among multiple DNS authoritative servers is one of the key issues arising with DNS server load balancing and optimization. The contribution of this paper can be summarized as: (1) An analytical model of RTT-sensitive server selections is proposed; (2) A server load estimation method is proposed based on server selection classification, which uses a DNS server fingerprint approach to identify RTT-sensitive server selections from BIND's; (3) Under BIND server selection algorithm, an iteration method is proposed to solve the server selection model, which is validated by the simulation results.

Conflict of interests

The author(s) have not declared any conflict of interests.

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Scientific Research and Essays

Case Report

Interesting finding of hyperpyrexia relieving post-stroke spasticity: A case report

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As an important cause of disability in adults, post-stroke spasticity (PSS) is a big challenge for the clinician and the effective management of spasticity should be necessary and essential for patients. We herein present a rare case of hyperpyrexia caused by upper respiratory tract infection which obviously relieved post-stroke spasticity (PPS), inspired by this, hyperthermia might be a new good way to relieve spasticity.

Key words: Post-stroke, hyperpyrexia, spasticity.

INTRODUCTION

post-stroke spasticity (PSS) is emerging as an urgent issue for stroke survivors, and is greatly associated with severe impairments, dis-function, and low health-related quality of life. Consequently, more and more rehabilitation resources are used in relieving the condition (Cousins et al., 2009). Treatment interventions for post-stroke hypertonicity include stretching, splinting, strengthening of antagonist muscles, oral medications, focal injections (phenol or botulinum toxins) and, less commonly, surgery (Marciniak, 2011). Following, the interest that we will describe, perhaps will make us transform the idea of relieving spasticity, we found that hyperpyrexia can relieve post-stroke spasticity in this case.

CASE REPORT

A 51-year-old woman was admitted to the emergency room in our hospital because of a sudden onset of headache and left hemiplegia. Immediate, CT scan showed an intra-cranial hemorrhage on the right side of the basal ganglia (Figures 1 and 2). After six hours, she accepted the surgery, and the surgery went well. Two weeks later, to further improve the physical activity, she was transferred to rehabilitation ward. Baseline rehabilitation evaluation and assessment revealed: Broca aphasia, hemidysesthesia, motor function: Fugl-Meyer assessment (10 points), Brunnstrom assessment (left upper/lower extremity and left hand:scale I), and the muscle tone of the left side: hypotonia. Activities of daily living were evaluated with Barthel index: 10 point. She received systematic rehabilitation treatment, after 3 months, muscle tone increased, modified ashworth scale showed that: left upper /lower extremity: scale II, left hand I^+) many measures were taken to relieve spasticity: continuous passive traction, Myonal (the maximum application was 300 mg per day)/ botulinumtoxin type A(100 µ local injected in left biceps) and local hyperthermia

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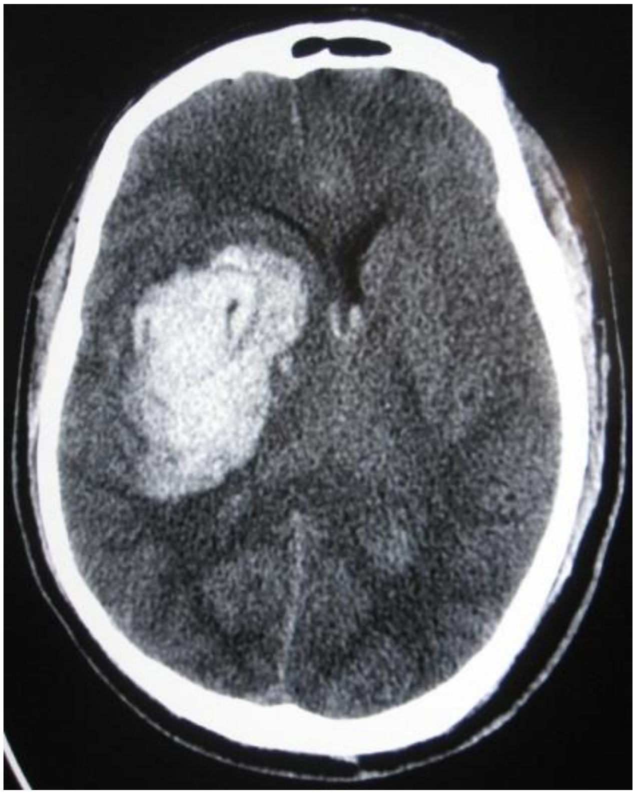

Figure 1. Preoperative CT scan. The intra-cranial hemorrhage in the right side of the basal ganglia.

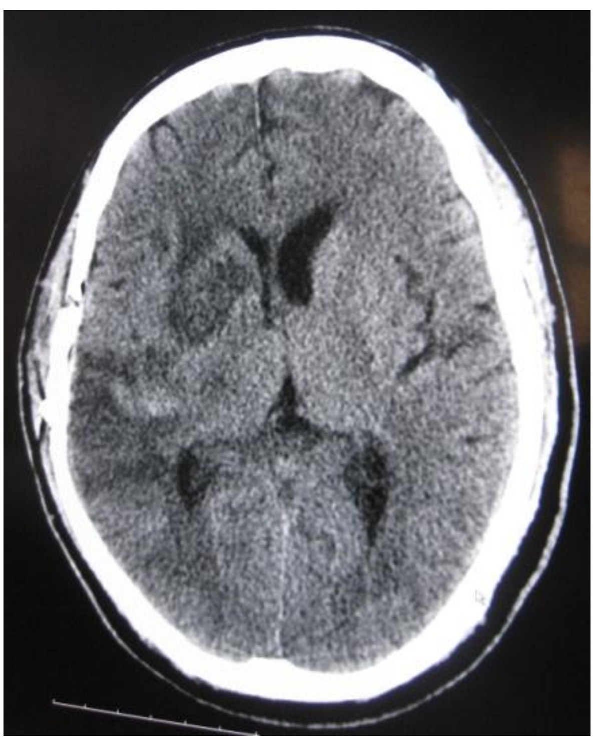

Figure 2. The CT findings after the right basal ganglia hematoma removal surgery.

therapy (Wax therapy on the left upper extremity) to relieve hypertonia. However, the effects were temporary and not so obvious. 15 months after brain hemorrhage, the patient suffered from upper respiratory tract infection, and developed flu symptoms with a temperature of 39.4°C, with malaise, headache and anorexia. 5 min later, she was given indometacin 50 mg externally. After 1 h, the symptoms gradually relieved her, and there is no use of other drugs. The next day, surprisingly and interestingly, Hemiplegic limb spasticity was obviously relieved. Rehabilitation evaluation revealed: Broca aphasia, motor function: Fugl-Meyer assessment (47 points), Brunnstrom assessment (left upper/lower extremity:scale III+; left hand:scale IV), and the muscle tone of the left side: Modified ashworth scale showed that: left upper /lower extremity: scale I^+ left hand I. Activities of daily living was evaluated with Barthel index: 55 point. Hemiplegic limb spasticity was obviously relieved. This situation sustained for about 1 month.

DISCUSSION

Spasticity is defined as “disordered sensorimotor control, resulting from an upper motor neuron lesion, and presenting as intermittent or sustained involuntary activation of muscles” (Pandyan et al., 2005). The mechanisms of spasticity were not completely understood, post-stroke spasticity (PSS) is a polysynaptic muscle reflex caused by abnormal processing of proprioception in the spinal cord (Sherman et al., 2000), also it is thought to be related to change in the balance of excitatory and inhibitory inputs to the motor neuron pool (Ozcakir and Sivrioglu, 2007). General consensus is that PSS seriously impacts post-stroke victims. Motor ability and activity performance is closely relative with the PSS, some of the secondary complications, such as contracture, pain, and weakness also caused by PSS, which might further contribute to post-stroke disability (Sommerfeld et al., 2004). However, heterogeneity across studies and epidemiological data regarding PSS were limited, it was difficult to qualify the prevalence and impact of PSS. Data obtained from some clinical studies, the prevalence of PSS ranged from 4 to 42.6%, and the rate in the chronic phase of stroke (>3 months) was highest (Brainin et al., 2011).

In clinical practice, a large variety of treatment options can be used to relieve post-stroke spasticity, and multidisciplinary interventions after stroke often lead to best clinical outcomes. The measures adopted in the former patient include continuous passive traction, baclofen, Botulinum toxin A and local hyperthermia therapy. However, the effects were temporary and little, until after a hyperpyrexia the PSS was obviously relieved. Based on professional, Botulinum toxin A producing a functional response that generally lasts from 3 to 6 months (Dolly, 2003), and the PSS obviously relieved over 7 months after injection. Indometacin were used to relieve hyperpyrexia only in one time, as we all know, the action time of the drug was no more than 1 day, so the possibility of relieving due to indometacin in the patient could be excluded. But there's another possible explanation for the effect, relieving of PSS was the natural course of stroke, as we outlined above, a month later, the PSS reappeared, that we can eliminate this possibility.

Clinically, thermotherapy (wax therapy for example) is considered appropriate option for post-stroke patient with spasticity, however, it often provide limited effects for short durations (several hours). As in this case, hyperthermia relieved PSS obviously and lasted for longer (about 1 month). Inspired by this, whole-body hyperthermia may be work better than local thermotherapy, and with different functional mechanisms. Shuji Matsumoto et al. determined the efficacy of thermotherapy for spasticity and found all F-wave factors of tibial nerve were lower post-treatment (Matsumoto et al., 2006) as we all know, F-wave amplitude is an indicator of alpha-neuron-excitability, which was actually altered by increased gamma-motor neuron activity. Hyperthermia play an important role in the decrease of spasticity might through to lower the activity of gamma afferent fibers through a nervous system response, and the relaxing of muscular and soft tissues. To our knowledge, investigation in to the anti-spastic effects of thermotherapy in post-stroke patients was rare. The mechanisms by which hyperthermia alter PSS are likely to be complex. The next step, further study will be necessary to evaluate the feasibility of clinical application of hyperthermia, as an economical and safe anti-spastic therapy for PSS. On the other hand, hyperthermia (natural or artificial) may cause excessive sweaty, long-term hyperthermia may present electrolyte disturbance and circulatory shock. We have to take precautions against negatively influences of hyperthermia.

In conclusion, we report an interesting case of hyperpyrexia caused by upper respiratory tract infection obviously relieved post-stroke spasticity, this interesting phenomenon was meaningful and thought-provoking and the underlying mechanisms should be further studied.

Conflicting of Interests

All authors declare that there is no conflict of interest.

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