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Comparison of Growth and yield of dry seeded rice (*Oryza sativa* L.) in natural and conventional farming systems

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ABSTRACT

The application of chemical fertilizers is costly and gradually lead to the environmental problems. Natural farming is becoming an increasingly important aspect of environmentally sound sustainable agriculture. In this regard, an experiment was conducted during Maha season in 2014 from November to February at Vaharai DS Division, Batticaloa, Sri Lanka. The experiment consisted of two farming systems; natural farming and conventional farming and was laid out in a Randomized Complete Block Design with twelve replications. All the crop management practices from land preparation to harvesting were done for each farming systems separately. Bg 352 rice variety was used for the experiment. Growth parameters and yield parameters were taken at fourteen weeks after sowing by destructive random sampling method. The results revealed that natural farming system significantly ($p<0.05$) increased the tested parameters such as plant height, total number of tillers, total number of productive tillers, total leaf area per plant, root length, dry weight of root, Panicle length, total number of spikelets per panicle, number of filled spikelets per panicle, hundred grain weight along with yield over conventional farming system. Further, economic analysis of the data presented in this study showed that natural farming method for rice cultivation is the most economical and attractive option for farming community. The high yield grain and less cost of production per hectare were noted in natural farms (B/C= 4.82) as compared with conventional farms (B/C=2.39). Therefore, it could be concluded that the adoption of natural farming technology improves rice farmer's profit along with livelihood and this eventually reduces poverty through environmental friendly way.

KEYWORDS: *Conventional farming, economic analysis, natural Farming, rice, yield*

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1. INTRODUCTION

The Sri Lankan national economy relies heavily on agriculture. 10.8 percent of Sri Lanka's national GDP relies on agriculture itself (CBSL, 2013), especially the cultivation of rice. Grown in 870,000 ha (34% of total cultivated land area), rice reflects the balance in the environment and the achievement in people that isn't seen by any other crop.

Rice is also immensely influential in the diets of Sri Lankans as 45% of the total calories and 40% of the total protein requirement is acquired through the consumption of rice. On a slightly broader spectrum, the per capita consumption of rice is around 100 kg per year, based on the relative prices of rice, bread, and wheat flour in that given year (DOA, 2015).

Because of intricacy of rice cultivation, many procedures are used on the crops to acquire the final product. This further leads to the use of chemicals, such as urea, which is the most popular form of nitrogen fertilizer (60-70%) used in Sri Lanka (NFS, 2012). Using pesticides on crops is effective in reducing pests and weeds, and therefore decreasing damages done to the rice crop, so Sri Lanka has become highly dependent on such pesticides.

In 2013, the WHO-UN concluded in a report that Sri Lanka was highest user of pesticides per hectare in the world (Daily FT, 2014). Before that, the year of 2008 saw over 430,000 MT of urea being imported into Sri Lanka and used in a straight or mixed form. The following year resulted in a total annual cost of Rs. 26,935 million for the subsidy program, with expenditure on such fertilizer imports coming in at Rs. 55,000 million (NFS, 2012).

The conventional farming method, which is very popular in Sri Lanka, has had some detrimental effects on the natural environment of the country. Issues such as deterioration in soil quality, loss of biodiversity, a declining arable cropping system, poor quality of the products, and the concerns with humans' health have all been relevant to the conventional farming method (Shaxson, 2006).

Even though the unfairness of agrochemicals in farming has led to pollution of the environment and food at a questionable quality level, the spread of organic rice production in Sri Lanka has been limited to certain marginalized areas in the past decade (Rodrigo, 2015). On a more positive note however, growing public awareness has led to other alternative solutions in Sri Lanka's approach with agrochemicals. Still, there is an exigency to bring upon the alternative farming sector and ensure that a substantial contribution is made through the alternative farming sector towards rice consumption in Sri Lanka.

Natural Farming (NF) recognizes the abundance of nature and utilizes indigenous resources for production. Its basic philosophy is to maximize the inborn potential of a life form and its harmony with the environment by not interfering with their growth and development or forcing the crops to yield more than what they can (Rohini, 2011).

Based on principles of combining all aspects of all living things, NF has come up with a solid, yet environmentally friendly method to practice farming. The NF has successful farming inputs that have been effective in the cultivation of crops, more so than approaches using fertilizers and pesticides. Instead of having the disastrous effects that partner up normally with commercial agriculture, the NF strives to nurture the environment than to hurt it (Rohini, 2011).

Along with the potential benefits of improved crop quality and safety (Giles, 2004), NF is an alternative method for conventional farming. The NF offers a solution to eradicate many of the problems of conventional farming as well as reducing environmental stress and increasing the quality of soil (Pulleman *et al*., 2003; Macilwain, 2004).

With the goal of producing food without the involvement of synthetic "solutions" such as chemicals and fertilizers, NF relies upon tool such as, indigenous microorganisms but not excluding, crop rotations, crop residues, and animal wastes. Ultimately, NF is promoting biodiversity while enhancing the composition of the soil. Organic agriculture remains a topic in Sri Lanka without much public awareness. With only a few realizing the benefits of organic farming, consumer demand for organic farming also remained low. This research was designed to compare natural and conventional farming systems for rice in the aspects of product and feasibility, for there is a lack of research pertaining to the comparison of natural and conventional farming systems of rice production in Sri Lanka.

2. MATERIALS & METHODS

The experiment was conducted at the farmers' field in Vaharai DS division in Batticaloa district of Sri Lanka during *Maha* season from November 2014 to February 2015.

2.1. Experimental Site:

The research field belongs to the agro ecological region of low country dry zone in Sri Lanka. The mean annual rainfall ranges from 1600 mm to 1970 mm and temperature varies from 25 to 32 ^{0}C. The major soil type of the field is sandy regosol. Initially soil test was done to study the soil properties of research field. The results were as follows,

Table 1. Chemical Properties of Research Field Used For This Study

Soil properties	Values
Soil pH	7.9
Total Nitrate	0.1ppm
Available Ca	13 g/100 g
Mg	2.7 g/100g
K	260 ppm
Fe	0.39 ppm
Mn	0.75 ppm
Cu	3 ppm

2.2. Preparation of Indigenous Micro Organisms (IMOs):

2.2.1. Fermented Plant Juice (FPJ):

Equal weight of plant parts such as Moringa leaves, banana stem, buds and moist leaves were chopped into small pieces about 3 to 5 cm. Jaggery was added at half of the total weight of ingredients. They were mixed and covered by porous cloth for two hours. After that it was transferred to a clay pot up to 3/4th of its volume. Then a small stone was put in to the pot followed by it was covered and allowed to fermentation for five to ten days. After that it was filtered and stored in a glass bottle (Rohini, 2011).

2.2.2. Fermented Fruit Juice (FFJ):

One kg of fruits such as mango, banana and papaw were collected from locality and it was diced as much as quick and put in to the disinfected jar followed by 1.2 kg of chopped jaggery obtained from palm sap was added. After that it was stirred two to three times by wooden stick. Then it was covered by porous paper and allowed for fermentation for seven to ten days. Prepared juice was poured in to glass bottle and it was stored under shade (Rohini, 2011).

2.2.3. Fish Amino Acid (FAA):

One kg of fish trashes were collected and cut in to small pieces followed by 1 kg of jaggery was chopped and mixed with fish trashes in a clay pot. After that it was covered by mosquito net and allowed for fermentation for seven to ten days (Rohini, 2011).

2.2.4. Oriental Herbal Nutrients (OHN):

One kg of ginger or garlic or cinnamon and one kg of jaggery obtained from palm sap were mixed in a clay container and it was covered by paper. The fermentation process was finished nearly at the end of five days. After that the beer was added up to half of the pot. Finally it was filtered after ten days and stored in a glass bottle under shade (Rohini, 2011).

2.2.5. Water-soluble calcium phosphate (WS-CaPo):

Initially animal bones were boiled to rid of the fat and meat. Then One kg of charcoal was prepared from boiled animal bones. After that vinegar was poured in to the jar containing charcoal until no bubbles pot are formed. The mixture was kept for thirty days. Finally the end product was stored in a bottle (Rohini, 2011).

2.2.6. Water-Soluble Calcium (WS-Ca):

One kg of crushed egg shell was roasted and put in to the clay pot followed by vinegar was poured until all the egg shell immersed in to the vinegar. It was kept for three days to dissolve the entire egg shells. Finally it was stored in a glass bottle (Rohini, 2011).

2.2.7. Indigenous Microorganisms (IMO):

A wooden box of Length 21 inches, Width 8 inches, Height 4 inches was made with ½ an inch thickness wood. It was filled with steamed rice up to 3 inch height. Then wooden box was covered with white plain paper. This wooden box was placed under excavated pit with the dimension of 12 inches in length, 8 inches in width and 2 inches in depth.

The box was kept for 5 to 7 days. After 5 to 7 days box was removed from that pit and sugar and turmeric powders were added. After that it was covered by paper and allowed for another 10 days. End product was transferred and stored in a bottle (Rohini, 2011).

2.3. Experimental Design:

The experiment consisted of two farming systems; natural farming and conventional farming and was laid out in a Randomized Complete Block Design with twelve replications. The experimental plot size was 25 square meter and each of the experimental plot had 5m alley path.

2.4. Crop management practices:

2.4.1. Natural farming:

Initially two mild ploughs were done at one week interval. After that IMO, FFJ and FAA were added in to the soil as soil application with the dilution rate of 1:1000 at the time of planting. Two days after application, rice seeds (Bg 352) were sown at the seed rate of 300 kg/ha. The application of IMO to the soil was done four times during the experimental period from two weeks after sowing to up to fourteen weeks after sowing at four weeks interval. The WS-CaPo was applied to the soil as soil application at seven week after sowing of rice.

The Application of WS-Ca was done two times; seven and ten weeks after sowing of rice. Soil drenching of FPJ was done at two, five, eight and eleven weeks after sowing of rice crop. Weeding was done manually, at ten to fourteen days after sowing. Further, OHN mixture was applied at two, five, eleven and fourteen weeks after transplanting as pesticide to rice crops under natural farming system.

2.4.2. Conventional farming:

Firstly, two deep ploughs were performed at one week interval. Immediately after ploughing basal fertilizer application was done at the rate of 120 kg/ha of TSP, 20 kg/ha of K2O and 5 kg/ha of N. Remaining nitrogen was applied as topdressing at two weeks after sowing, five weeks after sowing and at panicle initiation stage with the rate of 35 kg/ha, 55 kg/ha and 25 kg/ha respectively. Weeding was done chemically, at ten to fourteen days after sowing.

2.5. Measurements:

Destructive random sampling method was used to collect the plants for further measurement. For that, the quadrate (1m^2 square frame) was thrown to the field and plants within the quadrate were uprooted. Sampling was done in this experiment at fourteen weeks after sowing.

Parameters such as plant height, total number of tillers per plant, number of productive tillers per plant, total leaf area per plant, Root length of rice, dry weight of root, panicle length, total number of spikelets per panicle, number of filled spikelets per panicle, hundred grain weight and yield per unit area. In addition, economical effectiveness was performed to both farming system separately. The economical effectiveness measurements of natural and conventional rice production were as follow:

Total variable cost (TVC) = Σ of cost of all variable inputs = cost of land preparation + cost of fertilizer + cost of human labour + cost of other inputs

Return above variable cost (RAVC) = Gross return – total variable cost (Where Gross return = returns from grain + return from straw)

Benefit cost ratio analysis (B/C ratio) = Gross margin/Total variable cost.

2.6. Statistical Analysis:

Prior to the detailed analysis, the data were tested normality. T test was carried out, to compare the growth and yield parameters of two farming system. "Minitab 14" statistical analytical package was used to analyze the data.

3. RESULTS & DISCUSSION

3.1. Effect of Different Farming Systems on Vegetative Performances of Rice

3.1.1. Plant height

The plant height is not a yield component in grain crops but it indicates the influence of various nutrients on plant metabolism.

Table 2. Effect of Different Farming System on Plant height of Rice

Farming systems	Mean (cm)	T-value	P value
Natural Farming	88.1	2.67	P<0.05
Conventional farming	75.40		

Effect of different farming systems significantly influenced on plant height. Mean plant height of natural farming system was 88.1 cm. Natural farming had highest plant height compared with conventional farming. This may have resulted from the mineralization of nitrogen from organic materials through microbial activity.

Some microbiologists believe that the positive effects, usually observed at the early stages of plant growth, were caused by the production of small amounts of highly active growth promoting substances and not by fixation of large amounts of nitrogen (Gray & Williams, 1971).

3.1.2. Total Number of Tillers and Productive Tillers per plant

Tillering is an important trait for grain production and is thereby an important aspect of rice growth improvement. Production of total number of tillers and total number of productive tillers in rice plant were also influenced by different farming systems. Natural farming had highest total number of tillers per plant and total number of productive tillers per plant compared with conventional farming.

From this study it was observed that, application of inorganic fertilizers is not necessary to produce effective tillers if we can supplement it with organic manures. However, organic sources offer more balanced nutrition to the plants, especially micro nutrients which has caused better affectivity of tiller in plants grown in natural farming. This was supported by Ayoub (1999).

Table 3. Effect of Different Farming System on Total Number of Tillers and Total Number of Productive Tillers of Rice

Farming systems	Total number of tillers per	Total number of productive tillers per plant
Natural Farming	9.11	8.43
Conventional farming	3.75	3.50
T- Value	3.63	4.15
P- Value	P<0.05	P<0.05

The productivity of rice plant is greatly dependent on the number of productive tiller (tillers which bears panicle) rather than the total number of tillers. In present investigation maximum number of fertile tillers and spikelet per panicle were observed in natural farming. Hasanuzzaman *et al*., (2010) also reported similar results in rice.

3.1.3. Total Leaf area per plant (cm^2)

Effect of different farming system significantly influences on leaf area. Natural farming had highest total leaf area per plant compared with conventional farming (Table 4). In case of any plant, leaves are important organs which have an active role in photosynthesis. To achieve high yield maximization of leaf area is an important factor. In present investigation we found that natural farming significantly increased the flag leaf length over conventional farming. Similar findings are reported by Hasanuzzaman *et al*. (2010).

3.1.4. Root length (cm)

Root growth is a very good indicator of the efficiency of the treatments applied in studying the plant growth. The maximum root length (17 cm) was observed in natural farming system. The differences in root length may be attributed to the improved soil chemical and physical conditions and better nutrient availability (Oussible *et al*., 1992).

3.1.5. Dry weight of root (g)

Effect of different farming system significantly ($p<0.05$) influenced on dry weight of root. The highest dry weight of root recorded in natural farming system. Fageria & Baligar (2005), and Fageria (2009) reported that N fertilization improved dry weight of root in crop plants, including upland rice. The positive effect of N on root dry matter has been previously documented (Fageria, 2008).

Table 4. Effect of Different Farming System on Leaf Area per Plant, Root Length and dry weight of root of Rice

Farming systems	Leaf area per plant (cm^2)	Root length (cm)	Dry weight of root (g)
Natural Farming	603	17.25	12.72
Conventional farming	278	12.19	4.10
T- Value	2.81	4.81	5.54
P- Value	P<0.05	P<0.05	P<0.05

3.2. Effect of Different Farming Systems on Reproductive Performances of Rice

3.2.1. Panicle length (cm)

Panicle length was significantly influenced by the different cultivation systems which are presented in Table 5. Under natural farming condition the highest panicle length (21.49 cm) was found. Hossain (2008) observed that the cultivars Kataribhog & Badshabhog produced 21.13 and 20.61 cm panicle length under green manuring conditions (15 t/ha).

Table 5. Effect of Different Farming System on Panicle Length, Total Number of Spikelets per Panicle, Total Number of Filled Spikelets for Panicle of Rice

Farming systems	Panicle length (cm)	Total Number of Spikelet's per Panicle	Total Number of Filled Spikelet's for Panicle
Natural Farming	21.49	145.5	106.6
Conventional farming	17.93	94.2	66.4
T- Value	5.33	4.01	3.71
P- Value	P<0.05	P<0.05	P<0.05

3.2.2. Total number of spikelets per panicle

Effect of different farming system significantly influence on total number of spikelets per panicle. Natural farming had higher total number of spikelets per panicle compared to conventional farming. These results support the findings of Hussain *et al*. (1999) who reported that increase in wheat and rice grain yield when EM application was carried out in combination with farmyard manure or mineral NPK .The higher grain yield in the present and earlier studies, when EM was applied in combination with organic matters, can be attributed largely to the activity of the introduced beneficial microorganisms, which enhanced the decomposition of organic materials and the release of nutrients for plant uptake. This may be the reason to increased total number of spikelets per plant.

3.2.3. Number of filled spikelets per panicle

Effect of different farming system significantly ($p<0.05$) influenced on number of filled spikelets per panicle. Mean Number of filled spikelets per panicle of natural faming system was 106.6. Natural farming had highest number of filled spikelets per panicle compared to conventional farming. Higa *et al.*, 2000 who reported the useful substances produced by these bacteria include amino acids, polysaccharides, nucleic acids, bioactive substances, and sugars, all of which promote plant growth and development. The metabolites are absorbed directly by plants. This might be the reason to increased number of filled spikelets in natural farming system.

3.2.4. Hundred seed weight (g)

Effect of different farming system significantly influenced on hundred seed weight. Mean hundred seed weight of natural faming system was 2.713 g. Natural farming had higher hundred seed weight compared to conventional farming. Mayint (1994) reported that application of green manure as organic amendments increases the yield component in rice plants.

3.2.5. Yield (g/m^2)

Effect of different farming system significantly influenced on yield of rice. Mean yield of natural faming system was 601.5 g/m^2. Natural farming had highest yield compared to conventional farming.

Higa *et al.*, 2000; Hussain *et al.*, 2002 reported microorganisms in EM improve crop health and yield by increasing photosynthesis, producing bioactive substances such as hormones and enzymes, accelerating decomposition of organic materials and controlling soil-borne diseases. Higa *et al.*, 2000; also reported the useful substances produced by these bacteria include amino acids, polysaccharides, nucleic acids, bioactive substances, and sugars, all of which promote plant growth and development. The metabolites developed by these microbes are absorbed directly by plants. This may be the reason to increased rice yield in natural farming system.

Table 6. Effect of Different Farming System on Hundred Grain weight and Yield of Rice

Farming systems	Hundred grain weight (g)	Yield (g/m^2)
Natural Farming	2.713	601.500
Conventional farming	1.928	459.000
T- Value	4.84	3.46
P- Value	P<0.05	P<0.05

3.3. Economic analysis of different Farming Systems

Total cost was Rs.39,893.06/ha in the natural farming system, significantly lower than that of Rs.62,000.00/ha in conventional farming system. Gross margins were Rs. 192,464/ha in the natural farming system, significantly higher than that of Rs. 146,880/ha in conventional farming systems.

Benefit-cost analysis calculated shows that natural farming was economically the most feasible (B/C= 4.82) and attractive option as compared to conventional farming (B/C=2.36) for farming community. Chaudhary *et al*., 2002 and Singh, *et al*, 2002 also used benefit cost ratio to determine viability of zero tillage and their findings are in full agreement with the present results of the bread-up of total cost of production in rupees per hectare, farmers were investing significantly less on land preparation and fertilizer cost per hectare, which is major source of reduced working cost in zero tillage as compared to conventional farming of rice.

Table 7. B/C ratio of production of Rice under Different Farming Systems (Rs/ha)

Attributes	Natural farming	Conventional farming
Seed Cost (Rs/ha)	10 500.00	10 500.00
Cost of Ploughings (Rs/ha)	5000.00	12 500.00
Liquid solution cost (Rs/ha)	3 939.00	-
IMO cost (Rs/ha)	5 454.00	-
Fertilizer Cost (Rs/ha)	-	6 000.00
Chemical cost (Rs/ha)	-	18 000.00
Harvesting cost (Rs/ha)	15 000.00	15 000.00
Yield in kg per hectare	6 014.50	4 590.00
Total cost of production in (Rs/ha)	39 893.06	62 000
Gross Margins in Rs. Per hectare	192 464.00	146 880.00
Benefit cost ratio	**4.82**	**2.36**

4. CONCLUSIONS

Findings of the experiment showed that natural farming system have a significant influence on growth and productivity of rice. Further, benefit-cost analysis calculated displays that natural farming system is economically the most feasible (B/C= 4.82) and attractive option as compared to conventional (B/C=2.36) for farming community.

Therefore it can be concluded that the use of natural farming is an ecofriendly technique is probably one of the best ways to increase production of the rice crop and also for the reduction of cost of production of rice crop per hectare. It is needed to repeat same experiment for *yala* season is recommended in order to confirm the present findings.

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