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Evaluating the Effects of Integrated Use of Organic and Inorganic Fertilizers on Socioeconomic Performance of Upland Rice (Oryza Sativa L.) in Tselemti Wereda of North-Western Tigray, Ethiopia

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Abstract
As agriculture is a livelihood, the social and economic outcomes are of paramount importance. A variety of biological and economic interactions between crop and livestock make crops-livestock integration appealing to the Ethiopian farmers. The ever-increasing price of inorganic fertilizers (IF) is becoming a main problem for majority of farmers. Hence there is a need for alternative low cost soil fertility enhancing technologies. Based on this fact, both field experiment and survey were conducted during 2011/12 cropping season to evaluate the effect of integrated application of inorganic fertilizers and FYM on socioeconomics of upland rice. For the field experiment, a 4x3 factorial experiment consisting of four levels of inorganic fertilizers (0, 25, 50 and 75 kg/ha) and three levels of FYM (0, 6 and 9 t/ha) was laid out in RCB Design with three replications. Rice (variety: NERICA-3) was planted in rows. The results revealed that the higher agronomic yield (4440 kg/ha) did not brought highest profit because the value of the increase in yield is not enough to compensate for the increase in costs. The highest MRR (2018%) was between treatments 1 and 9 and use of 6t/ha of FYM with no inorganic fertilizer. Hence, FYM could be used instead of inorganic fertilizers to get higher net economic benefit but due to the problem of unavailability of FYM in excess amount, farmers could use the third highest MRR which is 1356%. Hence, it would be reasonable to conclude that integrating FYM along with inorganic fertilizers would be the best alternative because this not only increased the rice yield but also improved the fertility status of the soil, and could save part of the money that would have been paid for the greater doses of the chemical fertilizer and is socially acceptable. The perception of the respondent farmers to inorganic fertilizers showed that 76% of the respondents had no willingness to use inorganic fertilizers at full dose.
Keywords: FYM, Inorganic fertilizers, ,Integrated Nutrient Management, Marginal Rate of Return, Farmers' perception, Sustainability, Upland Rice, Ethiopia.

1. INTRODUCTION

During the past fifty years, agricultural development policies have been remarkably successful at emphasizing external inputs, such as pesticides and inorganic fertilizers as the means to increase food production quantitatively without taking into account the adverse ecological, socioeconomic and environmental effects they had (Lichtfouse *et al.,* 2011; Khosh, 2004; Moghaddam, 2005; Roling and Pretty, 1997). But during the 1980's, it was felt that the high productivity of the conventional agriculture had been achieved at the cost of massive damage to the natural environment and troublesome social disruptions (Alonge and Martin, 1995). Generally, agriculture of this period emphasized on productivity i.e. the focus of production was mainly on the "product" and not on the "process" (Moghaddam, 2005). Hence, despite the dramatically quantitative achievements of modern agriculture, in the early of 1980s, the green revolution technologies were criticized seriously (Rahman, 2003). As Rahman (2003) quoted, delayed consequences of the Green Revolution technology on the environment and the question of sustainability of agricultural growth received priority only recently. It is crucial that agricultural performance must evaluated according to the holistic principles of sustainable production systems (Bagheri *et al.,* 2008). Sustainable agriculture has been defined and described in many ways; despite the diversity in conceptualizing sustainable agriculture, there is a consensus on three basic dimensions of the concept, namely: ecologically sound, economically viable and socially acceptable (*ibid*). Any new technology can be evaluated in terms of its impact on the productivity, profitability, acceptability and sustainability of farming systems; and clearly these criteria are interdependent and all have biological, economic and social dimensions, although the attention devoted to each criterion has differed both among disciplines and over time (Duncan *et al.,* 1990).

In a world of growing complexity, it is becoming ever more obvious that the economic, environmental, technological, political and social problems of our times are systemic and cannot be solved within the current fragmented and reductionist model of our academic disciplines (Gliessman, 2007). That is, if only agronomic aspects are evaluated, this can lead to distorted decision-making, which in turn, can lead to economic and social dumping (Bagheri *et al.,* 2008).

The impact of increased fertilizer use on crop production has been large, but ever increasing cost of energy is an important constraint for increased use of inorganic fertilizer particularly for resource poor farmers

(Lay, 2002; Assefa, 2005). Use of chemical fertilizers is an essential component of modern farming but sustainable production of crops cannot be maintained by using only chemical fertilizers; and similarly FYM has long been recognized the most desirable organic fertilizer to improve soil quality but it is not possible to obtain higher crop yield by using organic manure alone due mainly to their unavailability in excess amount (Sarker *et al.,* 2011). Therefore, an integrated nutrient management in which both organic manures and inorganic fertilizers are used simultaneously has been suggested as the most effective method to maintain a healthy and sustainable soil system while increasing crop productivity (Bodruzzaman *et al.,* 2010).

For Ethiopia, as a new rice grower country, it is important to know how rice reacts with the farming system and to the social and physical environment (Tareke, 2010). FYM is an important organic resource for agricultural production in crop-livestock based farming systems (Hailu, 2010). Thus, there is a lot of potential for use of farmyard manure in the fertilizer schedule of rice and to reduce total dependence on inorganic fertilizers. However, no such study has been done so far for adoption of Integrated Nutrient Management (INM) technologies in Tigray region. The present research was therefore, conducted to study the influence of separate and combined application of farmyard manure and inorganic fertilizer on soil fertility, agronomic (growth, yield and yield components) and socioeconomic attributes. The results obtained in the analysis are used to develop recommendations for sustainability of rice cropping systems.

1.2. Statement of the Problem

Tigray is classified in the World Bank (2007) as a drought-prone area with inadequate and unreliable rainfall. Fertilization may not be profitable when water is the first limiting factor. So far application of fertilizer to mitigate problems of nutrient limited yields in Ethiopia has been based on conventional blanket recommendations, without taking in to account the possibility of indigenous nutrient supply. Moreover, use of different soil fertility options depends on the social set-up and economic status of farmers. Rice production in Tselemti Wereda is becoming an important asset for food security. Intensive rice mono-culture using only agrochemicals may lead deteriorating soil fertility, and declining rice productivity (Quang *et al.,* 2006). Furthermore, farmers are arguing that the price of the inorganic fertilizers is getting up and the increased rate is having burning effect on crops. On the other hand the use of FYM is constrained by its unavailability. Therefore, it is important to integrate and use minimum rates of both the organic and inorganic fertilizers so as farmers use them to the best of their indigenous knowledge in coping with such sustainability problems. Therefore, the present investigation was undertaken to observe the performance of the integrated use of farm yard manure (FYM) and chemical fertilizers to sustain soil fertility, rice productivity and the existing socioeconomic set-up in rice cropping system by giving options that match with their complex agricultural systems and socioeconomic status.

1.3Objectives of the Study

- to determine the economic viability of integrated use of organic and inorganic fertilizers on upland rice productions and
- to assess the perception of farmers towards the integrated use of organic and IFs in upland rice production.

1.4. Significance of the Study

The top-down extension system in Tigray and in Ethiopia in general is confined with the increased use of external inputs such as fertilizers and pesticides where little or no effort has been made to encourage farmers to use locally available resources of plant nutrients such as FYM. All extension initiatives have focused on the dissemination of the same recommendations for fertilizer use to farmers under all kinds of socioeconomic conditions and across all agro-ecological zones. However, fertilization needs to be rationally used because unwise application of fertilizers negatively affects the soil fertility, future crop productivity and farmers' economy (Lichtfouse, 2011). Moreover, no research has been done in this area of interest regarding the integrated use of organic and inorganic sources of plant nutrients in rice production and encouraging farmers in using locally available resources. The importance of this study is therefore to rice producers and to all actors in rice research and extension system. Since Tselemti wereda is rice basket of the region, detailed information on how the rice production is currently functioning and identifying the pros and cons of the production system helps governmental and non-governmental organizations to redesign appropriate intervention measures. Besides, since Maitsebri Agricultural Research Center (MyARC) is established in this wereda and is conducting rice research in the region, the information contained in this study could also partially fill the gap in rice production and the questions of future sustainability of the crop and socioeconomic aspects of farmers in general and the poor farmers in particular. Furthermore, the document also would serve as a reference for researchers to embark upon similar or related research works in other parts of the region and the country.

1.5 Hypothesis

H_a: Integrated use of organic and inorganic fertilizers can positively and significantly sustain the socioeconomic setups in rice production due to their positive interactions and complementarities between them.

1.6 Research Questions

- ✓ Is the use of inorganic fertilizers economically feasible?
- ✓ What does farmers' perception regarding the use of inorganic fertilizers and FYM look like?
- ✓ What are the potential and limitations of the use of Farm Yard Manure (FYM) for Rice production?
- ✓ Why most farmers are not willing to demand (purchase) inorganic fertilizers?

2. REVIEW OF RELATED LITERATURE AND STUDIES

The challenge for agriculture over the coming decades will be to meet the world's increasing demand for food in a sustainable way (Snyder and Spaner, 2010). Declining soil fertility and mismanagement of plant nutrients have made this task more difficult. As long as agriculture remains a soil-based industry, major increases in productivity are unlikely to be attained without ensuring that crop plants have an adequate and balanced supply of nutrients (Peter *et al.,* 2000).

The concept of sustainable agriculture is a relatively recent response to the decline in the quality of the natural resource base associated with modern agriculture (Audirac, 1997). Today, agricultural production does not get evaluated in purely technical terms but also with regard to a more complex set with social, cultural, political and economic dimensions (Lichtfouse, 2011). The sustainability concept has prompted much discussion and has promoted the need to propose major adjustments in conventional agriculture to make it more environmentally, socially and economically viable and compatible (Gliessman, 2007).

Inorganic fertilizers supply only nutrients and exert no beneficial effects on the soil's physical condition; moreover, the continuous and unbalanced use of inorganic nutrients from the chemical fertilizers under intensive cropping system has been considered to be the main cause for stagnating or declining crop productivity (Guggari and Kalaghatagi, 2000; Mathew and Karikari, 1990). Similarly, Shivanand (2002) reported that application of organic materials like FYM, compost or green manure in combination with inorganic fertilizer improved soil physical and chemical properties; available N, P, and K were increased significantly with organic materials in conjunction with inorganic materials.

The sustainable agricultural system is based on minimizing the use of costly external inputs, such as synthetic fertilizers and pesticides, by increasing and efficiently utilizing farm-based resources (Ramesh *et al.,* 2005). It is based on minimal use of off-farm inputs and on management practices that restore, maintain and enhance ecological harmony. The use of organic and locally available sources of plant nutrients in agriculture is a sustainable and environmentally friendly production system that offers the world in general and poor farmers in particular with a wide range of economic, environmental, social and cultural benefits (Ntanos and Koutroubas, 2002; UN, 2008; Astaraie, 1996). An experience from India has indicated very good results to increase rice production. Using 5.6 tons of animal manure fertilizer caused 47% yield increase and using same rate of nitrogen of 67 kg/ha caused yield increase in 63% and the combined use of organic and chemical fertilizers together increased yield in 118% (Rehana *et al.,* 2003). In china at low fertility soil conditions, using of 15 tons animal manure fertilizer with 70 kg/ha nitrogen caused increases wheat production by 40% (Malakoti, 1996).

2.1 Rice and its Global Food Supply

Rice (Oryza sativa L.) has supported a greater number of people for a longer period of time than any other crop since it was domesticated (Fairhurst and Dobermann, 2002). Unlike maize or wheat, less than five percent of total rice production is traded on world markets. Thus, the emphasis in all rice economies is on self-sufficiency. Because of its political, economic, and social significance, rice self-sufficiency and political stability are interdependent issues (Greenland, 1997).

Modern rice varieties give higher crop yields but respond to more nutrients than local varieties because of higher amount of potential biomass production. Bodruzzaman *et al.,* (2010) pointed out that farmers in less developed countries (e.g. Bangladish) use only about 102 kg nutrients/ha (70 kg N, 24 kg P_2O_5, 6 kg K_2O, 2 kg S+ Zn) annually for rice while the crop removal is 200 kg/ha and hence, soil fertility is declining.

2.2 Rice Uses and Research Status in Tigray, Ethiopia

Over 85 percent of the total populations of Ethiopia are rural smallholder and they dependent on mixed farming and practice rain-fed agriculture (Tewolde Berhan, 2006). The Ethiopian smallholder peasant agriculture accounts for more than 95% of the total food production. Majority (78%) of farmers are involved in crop-livestock (mixed) production systems (Feleke**,** 2002). A variety of biological and economic interactions between crop and livestock make crops-livestock integration appealing to the Ethiopian farmers.

Rice is among the basic targeted cereal commodities that have received due emphasis in the promotion of agricultural production and expected to contribute to ensuring food security in Ethiopia. Despite its relatively very recent history of cultivation in Tigray, rice is one of the potential grain crops that could contribute to the efforts for the realization of food security in the region (MyARC, 2010). The lowlands of Western and North Western Zones, some swampy areas of Southern Zone and irrigated areas in the East could be mentioned as some of the potential areas for rice cultivation in Tigray (Tareke, 2007). However, it is only during the last 4-5 years that the crop has got attention and started being tested in different parts of the region.

Rice is a highly adopted cereal crop in Tigray. In addition to its adaptability to Ethiopian climatic conditions, its amenability to various foods used by the Ethiopians makes it acceptable by farmers (MyARC, 2010). The fact that it can be made into '*injera' (fermented and flattened Ethiopian bread)*, *bread*, *porridge and local drinks* is good enough for its rapid adoption. Of course, this is in addition to rice being consumed boiled and mixed with different sauces as is done elsewhere in the world. The other important reason for its great adoption by farmers is the palatability of its straw for livestock (*ibid*). However, there are growing evidences that intensive rice production using only external fertilizers and with little or no use of organic manure will be a big question for researchers in the near future because of severe fertility deterioration of soils resulting in stagnating or even declining of crop productivity (Ali *et al.* 2009).

2.3. Farmers' Perception of Organic and Inorganic Fertilizers

As agriculture is a livelihood, the social and economic outcomes are of paramount importance (Pretty et al., 2010). Any new technology should be evaluated in terms of its impact on the productivity, profitability, acceptability and sustainability of farming systems (Gliessman, 2007; Roling and Pretty, 1997; Jackline, 2002). If a farmer's actual experience with the innovation is satisfactory, his/her perceptions probably will become more favorable. The current extension system in Ethiopia is along the lines of the Green Revolution approach to agricultural development (Elias, 2002). Use of mineral fertilizers is seen by the Ethiopian officials as the easiest and simplest way to improve soil fertility and hence increase agricultural productivity. All extension initiatives have focused on the dissemination of the same recommendations for mineral fertilizers use to all farmers under all kinds of socioeconomic conditions and across all agroecological zones; no nation-wide effort has been made to encourage farmers to efficiently use the locally available sources of nutrients such as manure (*ibid*). This is a clear indication that the agricultural policy of Ethiopia failed to realize the complex nature of soil fertility problems, the prevailing diverse social settings and economic status of farmers and the future negative impact of agrochemicals. Use of blanket recommended fertilizer on grain crops in Tigray consists of DAP in combination with Urea at the rate of 100 kg each ha^{-1} $year^{-1}$; however, the open willingness of farmers to demand inorganic fertilizers still remains very much low due mainly to economic constraints, fear of the burning effect and risk aversion (Hailu, 2010; Assefa, 2005).

Farmers' opinions towards the use of either organic or inorganic sources of plant nutrients are influenced by a variety of factors such as: information sources, ethical concerns about the environment, farmers' knowledge, economic considerations (cost and benefit aspects), marketing procedures, the rationale of the extension system and the like (Chouichom and Yamao, 2010). Many researchers reviewed lots of reasons that farmers are frustrated in using mineral fertilizer such as: the ever increasing price of mineral fertilizer is becoming beyond the purchasing power of farmers, the gradual soil's fertility depleting effect of inorganic fertilizers and fear of burning effect by chemical fertilizers on crops in case of moisture inadequacy (Hailu,2010). Generally, the frustration of the smallholder farmers is to escape possible crisis when the prices of their farm products are too low or lost in the unpredictable rainfall situation (World Bank, 2007).

Therefore, farmers are inclined into locally available resources and technologies such as use of FYM, crop rotation, soil and water conservation (e.g. terracing) and planting multipurpose trees than using mineral fertilizer (Hailu, 2010). For example, FYM does not need money but labor, which is locally available in each farming family of Ethiopia. It is easily understood technology. Of course FYM has labor requirement mainly for preparation, caring and transportation. But for many farmers, labor is not major obstacle because labour shortage can also be minimized at least by group work. This is because input costs continue to rise while the return from agricultural products fall (Indrani *et al.,* 2008). For example, Gruhn et al. (2000) reported that the domestic prices of mineral fertilizer in Africa are as such that one kg of nitrogenous fertilizer can cost between 6 and 11 kgs of grain. That is why some times farmers complain that using mineral fertilizer is a waste of money (Harris, 1998). Farmers of Tselemti wereda also argued that the market price of crops is much less than that of the inorganic fertilizers (personal observation). Integrated nutrient management practices are survival and risk avoidance strategies for farmers (Mahmood et *al.,* 1997). Many farmers understand the role of FYM in improving soil quality and sustaining yield. The existing cultural and social institutions of communities make labor demanding systems appropriate (Hailu, 2010). Farmers are looking for socio-economic independency at local level, which is better income without being trapped into debt problem (Somda *et al.,* 2002).

The conventional wisdom is that the best way to improve the productivity of resource poor farmers is through the use of high-yielding variety of crops and chemical fertilizer; however research evidences show that the resulting yield increases may not be sufficient to pay for these inputs (Christopher, 1994). The addition of any amount of fertilizer is interesting to farmers if and only if it is profitable through the enhancement of either yield or quality (Kiros, 2010). However, maximum profits are rare at maximum yields because the last increment of fertilizer to produce a little more yield may cost more than the yield increase is worth. Fertilization may not be profitable when water is the first limiting factor; and due to other hindrances such as market because an increase in yield may have less value compared to the cost of fertilizers (ibid).

Without economic analysis, one cannot have good idea about how long such a technology will persist in the face of rising household costs and increasing competition. Many new technologies, though technically acceptable, failed to function for a longer period of time because of their high financial requirements (CIMMYT, 1988). The economic analysis helps researchers to look at the results from the farmers' viewpoint (*ibid*). Partial Budget Analysis (PBA), as the name indicates, measures changes in income and returns to limited resources (inputs) that change along the treatments. It provides a limited assessment of risks and further more suggests a range of prices and costs at which a technology becomes profitable. PBA helps to carry out Marginal Rate of return (MRR) analysis which is important for the correct evaluation of alternative technologies, where the MRR analysis is carried out on both the treated and untreated (Control) treatments (CIMMYT, 1988). Often, a minimum rate of return is set as a base line above which the treatment options can be accepted and costs of capital, inflation and risk can be accounted for. A 100% minimum rate of return is considered as a minimum value up on which farmers could be willing to invest given their level of poverty and the fragile nature of the environment (*ibid*). This comparison is important to farmers because they are interested in seeing the increase in costs required to obtain a given increase in net benefits.

3. Research Methodology

3.1 Description of the Study Area

3.1.2 Location

Tigray, located in the northern tip of Ethiopia is bordered with Afar region in the East, Sudan in the West, Eritrea in the North and Amhara region in the South. It extends from $12^0 13'$ to $14^0 54'$ North latitude and from $36^0 27'$ to $40\ ^0 18'$ East longitudes (Figure 1). It covers an area of 102,000 km^2 and has more than 4 million inhabitants, of whom 85% are rural dwellers (CSA, 2006). Tselemti woreda is found in North Western Tigray administration zone of Tigray region. The field experiment was conducted at the research station of Maitsebri Agricultural Research Center located in Tselemti district The research station lies at $13^0$05’ North Latitude and $38^0$08’ East Longitude and has an altitude of 1350 masl. The main crops cultivated for consumption are sorghum, maize and millet and rice.

3.1.2 Socioeconomic Characteristics

Based on the 2007 national census conducted by the Central Statistical Agency (CSA, 2007) of Ethiopia, this woreda has a total population of 138,858, of whom 70,108 are men and 68,750 women. With an area of 3,858.66 square kilometers and 37,367ha cultivated land, Tselemti wereda has a population density of 35.99 people per square kilometer. A total of 30,485 households were counted in this woreda, resulting in an average of 4.55 persons to a household (*ibid*). According to the wereda bureau of agriculture and rural development (WBARD), the population of the sampled tabias (sub-districts), Tsaedakerni, Mezekir and M/alem have 5101, 4630 and 8500 total population; 666, 849, and 1100 male headed households and 67, 50 and 180 female headed households respectively.

The demographic characteristics of the respondents revealed that the farmers are low educated, fairly aged and much experienced in farming. About 41.3% of the respondents belonged to the age group ranging from 46-60 years old with minimum and maximum age of 28 and 78 respectively and an average age of 49.28 years. The farming experience of 90.7% of the respondents is more than 20 years. In the case of educational level, majority of the respondents are illiterate (49.3%), 1-6 years of formal schooling (40%), 7-12 years of formal schooling (6.7%) and non- formal education (4%). Regarding occupation, all of the respondents reported mixed agriculture as their major occupation. Whereas, due to small land holdings and need for additional income few of them had non- farm incomes which is basically traditional gold mining (TGM). Regarding landownership, 5% of the respondents were landless. The average land holding for households was 1.34 ha with minimum of zero and maximum of 3.25ha. About 32% of the respondent farmers have farm land of one and below 1ha and 92% of the households have farm sizes of 2 hectare or less. Majority of the respondents were small- scale farmers. Of the 75 sampled respondents about 90.7% were male headed and the remaining 9.3% are female headed households.

3.2 Experimental materials, Design and procedures

Field experiment and survey study were employed to get detailed information on the same issue (integrated use of organic and inorganic fertilizers). In this study both quantitative (the economic part) and qualitative methods (the social aspect) were employed. Semi-structured key informant interview was used to gather the required data. Rice cultivar ‘NERICA-3’ was used as planting material. The treatments consisted of a factorial combination of four levels of inorganic fertilizers and three levels of FYM. The experimental design used was RCBD in 3 x 4 factorial arrangements with three replications. A plot size of 1.4m x 3 m (4.2 m^2) was used. The blocks were separated by 1.5m, whereas plots within a block were 1m apart from each other. Each plot consists of 7 rows of 3m length, with a spacing of 20 cm between rows. The treatments were organic (FYM) and inorganic (DAP plus Urea) sources of plant nutrients with rice as a test crop. The sources of the inorganic fertilizers were DAP (Di-ammonium phosphate (18%N, 20%P) and Urea (46%N). Full dose of DAP and half of Urea were applied at the time of planting and the remaining Urea was side dressed at panicle initiation stage of the crop. The source of the manure was cattle manure. There were three levels of the organic fertilizer (FYM) i.e. FYM_1=9t/ha; FYM_2=6t/ha and no manure (Mo=control). Organic manure (FYM) was uniformly applied to each plot as per treatment. The inorganic fertilizer (IF) treatments were comprised of four levels: control (IF_O=no DAP and no Urea), IF_1=75kg/ha DAP + 75kg/ha Urea; IF_2=50kg/ha DAP + 50kg/ha Urea and IF_3=25kg/ha DAP + 25kg/ha Urea. The seed were sown at a depth of 2.5 cm and seed rate of 70kg/ha was used. All other cultural practices (ploughing, cultivation, seed rate, sowing method, weeding and others) were applied uniformly to all plots as per standard recommendations for the crop. The cropping history of the experimental field showed that it was sown with rice crop in the previous cropping year. Grain yield data were recorded after drying, threshing and cleaning of the grain. Straw yield was obtained by subtracting the grain yield from total above ground biomass yield. The Partial Budget Analysis (PBA) of the rice was computed by considering the costs of production that vary along the treatments, i.e. costs of inorganic fertilizers and the costs of collecting and distributing of FYM.

3.2.1 Methods of Economic Data Analysis

For economic evaluation of the cost and benefit in using the different combinations of organic and inorganic fertilizers, the Partial Budget Analysis (PBA), which includes the Dominance Analysis (DA) and Marginal Rate of Return (MRR), was used following the CYMMYT procedure (CIMMYT, 1998). In this study, the Partial Budget Analysis was made to determine the most economically acceptable treatment combinations by estimating the costs and benefits based on the current market price of rice, inorganic fertilizers and the transportation and spreading costs of farmyard manure. The varying labor costs were estimated based on the existing rate of payment to daily farm laborers. Grain and straw yield harvested from the experimental plots were converted into hectare bases. Subsequently, the market value of both components was based on the prevailed market price. To estimate economic parameters, rice was valued at an average open market price of 450.00 birr per quintal (100kg) of grain. Rice straw has high market demand and its market price on open market is 18 Eth. Birr (1 USD) per 'shekim'. 'Shekim' is local measure which is one head / back load by an adult person and weighs 20kg on average. Therefore, the price of one quintal (100kgs) (i.e. 5 'shekims') of rice straw is 90 birr (5x18birr) i.e. 5 USD. The straw yield of rice is estimated to be 88 'shekims' per hectare (Astewel, 2010). Hence, for the economic analysis of the rice straw, 90 birr (5 USD) per quintal is used. The price of 10 workdays (WD) per hectare for collection and transportation of FYM was used (Astewel, 2010) and wage rate of 35 birr (1.94 USD) per workdays was used. The price of inorganic fertilizers used is 1280.00 birr (71.11 USD) per quintal (100kgs) for DAP and 980.00 birr (54.44 USD) per quintal for Urea. Experimental yields are often higher than the yields that farmers could expect using the same treatments; hence in economic calculations yields of farmers are adjusted by 15% less than that of the research results (CIMMYT, 1998). The partial Budget analysis was undergone through the following stages:

3.2.1.1 Net Income: Estimate the net benefit arising from all alternative treatments. Net income (NI) or net benefit is calculated as the amount of money left when the total variable costs for inputs (TVC) are deducted from the total revenue (TR).

$$NI = TR - TVC$$

3.2.1.2 Dominance Analysis (identification and elimination of inferior treatments): Before proceeding with the calculation of Marginal Rates of Return, an initial examination of the costs and benefits of each treatment, called dominance analysis is important. Dominance analysis is used to eliminate some of the treatments from further consideration in the MRR and thereby simplifying the analysis of MRR. i.e., those treatments which involve higher cost but do not generate higher benefits (called **dominated** treatments) are eliminated. The dominance analysis was carried out by first listing all the treatments in their order of increasing costs that vary (TVC) and their net benefits (NB) are then put aside. Any treatment that has higher TVC but net benefits that are less than or equal to the preceding treatment (with lower TVC but higher net benefits) is **dominated *treatment*** (marked as "**D**"). The dominance analysis illustrates that to improve farmers' income, it is important to pay attention to net benefits rather than yields, because higher yields do not necessarily mean high net benefits.

3.2.1.3 The Marginal Rate of Return (MRR) is used to assess relative profitability among alternative treatments. It measures the percentage increase in net income in relation with each additional input of expenditure (ΔTVC) and the 100% rate of return is considered as a minimum value up on which farmers could be willing to invest given their level of poverty and the fragile nature of the environment (CIMMYT, 1998). MRR was calculated as the ratio of change in return of the average of each replicated treatment to the change in total cost with regard to the control. It compares the increments in costs and benefits between pairs of treatments.

$$\mathbf{MRR} = \frac{\Delta NI}{\Delta TVC} \mathbf{x100}$$

Where:

ΔNI = Change in Net Income;

ΔTVC = change in Total Variable Cost

The marginal rates of return appear in between two treatments. It makes no sense to speak of the marginal rate of return of a particular treatment because the MRR is a characteristic of the change from one treatment to another.

3.2.1.4 Identification of a candidate recommendation from among the non-dominated treatments. This is the treatment which gives the highest net return and a marginal rate of return greater than the minimum considered acceptable to farmers.

3.2.2 Methods of Social Data Analysis

The social data collected were analyzed with the aid of the descriptive statistical tools of frequency count and percentage. Simple descriptive statistics such as simple measures of central tendency, mean, standard deviation, frequency, percentages and cross tabulation were used for the survey data gathered from the sampled farm households. Statistical package for social science (SPSS) version 16 was employed to analyze the data. The analyzed data were presented using tables, graphs and charts.

4. RESULTS AND DISCUSSION

4.1 Effects of Organic and Inorganic Fertilizers on the Economic Benefit of Rice

Economic yields and added benefits as influenced by integrated use of chemical fertilizers and organic materials on rice have been calculated and presented in Table 1. The exchange rate of 1USD during this experiment was 18 Eth Birr. The highest grain yield of 44.4 Ql/ha and straw yield of 49.9 Ql/ha was recorded in treatment 6. On the basis of the prevailing prices of inputs and outputs during the cropping season, the economic analysis revealed that the highest mean net return of birr 18867.24 per hectare was recorded for the plot that received 9t/ha FYM together with 75kg/ha of the recommended dose of inorganic fertilizer which is birr 7240 more than the net returns from the control (birr 11627.24). The second highest mean net benefit of birr 16567.41 per hectare was obtained from plots that received 9t/ha FYM and no dose of recommended inorganic fertilizers. On the other hand, the lowest net return (11627.24 birr/ha) was obtained with the control treatment (Table 1). These observations are in agreement with those reported from Kenya by Makokha *et al.* (2000). High net return from the foregoing treatments could be attributed to high yield and the low net return was attributed due to low yield.

Table 1: Result of the Total Variable Cost (TVC) and Net Benefit (NB) as influenced by integrated use of chemical fertilizers and organic materials on rice

trts	FYM (t/ha)	IF (kg/ha)	Gross Return (birr/ha)	TVC (birr/ha)	Net Return (Birr)	Net Return over control
trt1	0	0	11627.24	0.00	11627.24	Xxx
trt2	0	75	17938.49	1695.00	16243.49	4616.25
trt3	0	50	16042.05	1130.00	14912.05	3284.82
trt4	0	25	13809.02	565.00	13244.02	1616.78
trt5	9	0	16812.41	245.00	16567.41	4940.17
trt6	9	75	20807.24	1940.00	18867.24	7240.00
trt7	9	50	17306.60	1375.00	15931.60	4304.36
trt8	9	25	17044.97	810.00	16234.97	4607.73
trt9	6	0	15333.66	175.00	15158.66	3531.43
trt10	6	75	18171.81	1870.00	16301.81	4674.58
trt11	6	50	17464.95	1305.00	16159.95	4532.72
trt12	6	25	14919.80	740.00	14179.80	2552.56

KEY: FYM= Farmyard Manure; IF= Inorganic Fertilizer; TVC=Total Variable Cost; MRR= Marginal Rate of Return; 1 USD = 18 Ethiopian Birr).

From the agronomic point of view, it was apparent from the above results that 9 t/ha of FYM in conjunction with 75kg/ha of the recommended dose of inorganic fertilizer yielded better than the rest of treatment combinations which is 44.4Ql/ha.

The dominance analysis for integrated use of FYM and inorganic fertilizers is shown in Table 2. As per the procedure needed for dominance analysis, the treatments were arranged in their order of increasing total variable cost (TVC) and their corresponding benefits were put aside. Treatment 1 showed the least TVC and treatment 6 showed the maximum TVC (1940 birr) and all the remaining treatments were confined between these two ranges. As is clearly indicated in Table 2, as one goes from treatment 1 to treatment 9 and then to treatment 5, the TVC as well as the net profit increased for all the treatments. But for treatment 4 through treatment 10 the TVC increased and they all showed lower net benefits than treatment 5 (birr 16567.41). That is treatment 5 had minimum TVC (birr 245) but highest net benefit than these treatments, and hence all these treatments are dominated and signed as "D" and finally not considered for further analysis of MRR. However, the last treatment (Trt 6) had both higher TVC and net benefit than treatment 5 and hence not dominated and was considered for MRR. Therefore, based on the principles of dominance analysis, only four treatments (1, 9, 5 and 6) have passed for the final analysis of MRR (Table 2). Here it is worth mentioning that (Table 2) the yields of treatments 2, 7, 10 and 11 are higher than those of treatment 5 (36.66Ql/ha), but the dominance analysis showed that the value of the increase in yield is not enough to compensate for the increase in costs (TVC) of these treatments. Kiros (2010) also indicated that the addition of any amount of fertilizer is interesting to farmers if and only if it is profitable through the enhancement of either yield or quality; and maximum profits are rare at maximum yields because the last increment of fertilizer to produce a little more yield may cost more than the yield increase is worth.

From Table 2, use of FYM at the rate of 9t/ha and 6t/ha and the use of 9t/ha of FYM in conjunction with75kg/ha of inorganic fertilizers could be considered to have an economic advantage over the use of other alternative combinations. Hence, to improve farmers' income it is important to pay attention to net benefits rather than yields because higher yield does not necessarily mean high net benefit (Table 2).

Table 2: Dominance Analysis for Integrated use of FYM with Inorganic Fertilizers (1Ql= 100kgs).

Trt #	**Combinations**		**Grain Yield (Ql/ha)**	**TVC (birr)**	**Net Benefit (birr)**	**Dominance (D)**	**MRR (%)**
	FYM	IF					
trt1	0	0	24.27	0	11627.24	-	
trt9	2	0	33.40	175	15158.66	-	2018
trt5	1	0	36.66	245	16567.41	-	2013
trt4	0	3	29.25	567	13244.02	**D**	-
trt12	2	3	31.97	740	14179.80	**D**	-
trt8	1	3	35.80	810	16234.97	**D**	-
trt3	0	2	34.60	1130	14912.05	**D**	-
trt11	2	2	37.11	1305	16159.95	**D**	-
trt7	1	2	37.01	1375	15931.60	**D**	-
trt2	0	1	38.11	1695	16243.49	**D**	-
trt10	2	1	38.70	1870	16301.81	**D**	-
trt6	1	1	44.40	1940	18867.24	-	135.6

Key: Trt= Treatment; TVC= Total Variable Cost; D= dominated; MRR= Marginal Rate of Return;Q= Quintal (100kgs);
FYM=manure; IF=inorganic fertilizer (DAP + Urea).

Finally, MRR was calculated for the four treatments that showed no dominance (i.e. 1, 9, 5 and 6) to compare the increments in costs and benefits between pairs of treatments. The highest MRR was recorded between treatments 1 and 9 which is 2018%. This means these two treatments (trt 1 and 9) had change in net income of 3531.42birr (i.e. 15158.66-11627.24) and change in TVC of 175 (i.e. 175-0). The rate of return for these two treatments is therefore 20.18 birr which means that the rate of return is 2018% above the cost for additional input investment (TVC). That is if farmers invest birr 175 in using 60 Ql/ha of FYM with no inorganic fertilizer, they could recover the 175 birr plus an addition of birr 3531.42 which is 20.18 times the cost incurred (3531.42 = 175x20.18) or it is the difference in net benefit of treatment 9 and 1 (i.e. 3531.42 = 15158.66-11627.24). In this case, the marginal rate of return (MRR) for changing from Treatment 1 to Treatment 9 is 20.18 or 2018%. This means that for every 1birr invested in using 60 Ql/ha FYM and its application, farmers can expect to recover the 1birr and obtain an additional of 20.18 birr. The marginal rate of return (MRR) for going from Treatment 9 to Treatment 5 is 2013% (or birr 20.13 increment) which is relatively smaller than the highest MRR in this experiment (MRR b/n treatment 1 and 9). Thus, for incurring TVC of birr 245 in using FYM at a rate of 9 t/ha gave a marginal rate of return of 2013% i.e. for every one birr invested in the use of 9 t/ha FYM, it is possible to recover the one birr invested and an additional of 20.13 birr (i.e. 20.13 birr is 2013% of one birr). The third MRR of 135.6% was recorded between treatment 5 and treatment 6. This MRR of 1356% (or 1.356 birr increase) is much less than the previous ones.

4.4 Results of Social Perceptions

This chapter deals with the findings and descriptive statistics of the social issues on the use and perception of organic and inorganic sources of fertilizers on rice production in Tselemti district.

4.4.1 Farmers' Perceptions towards Organic and Inorganic Fertilizers

4.4.1.1 Farmers' Perception of Farmyard Manure

The study area is one of the potential livestock producing corners of the region. Due to this fact, there is high potential of using farmyard manure in the wereda. According to the respondent farmers, 98.7% of them use FYM for their general crop production. The farmers have their own amount (rate), methods and time of application based on the type of the crop to be grown. Since livestock manure is very much respected by the farmers, they apply to their major cereal crops such as sorghum, maize, finger millet and to some extent rice.

Table 3: Farmers use of farmyard manure (FYM) (N=75)

Question		Kebelle Name			Total	percent	x2	sig
		Tsaedakerni	Mezekir	M/alem				
Do you use manure?	Yes	33	22	19	74	98.7		
	No	0	1	0	1	1.3		
	Total	33	23	19	75	100	2.29	0.318ns
Do you use manure for rice production?	Yes	0	4	1	5	6.7		
	No	33	19	18	70	93.7		
	Total	33	23	19	75	100	6.67	0.036*

*Key: X^2= chi-square test; *= significant at $p<0.05$; ns= not significant*

According to the farmers, unless shortage of manure happens, there is no substitute for FYM. But, the use of high quality organic fertilizers is rarely practiced mainly due to management problems. The chi-square test indicated that there is no as such a significant difference among the farmers of the study kebeles (sub-district) in using or not using the farmyard manure because majority of the farmers use it. However, there is a significant difference ($p<0.05$; Table 3) among the three kebeles in the use of the FYM in rice production. Relatively more farmers in the Mezekir kebelle are using FYM for rice production .

Table 4: Reasons why farmers do not use manure on rice

S.N	Reasons	Frequency	Percent
1	Priority to other crops	27	36.0
2	lack of knowhow on the use of FYM on rice	17	22.7
3	Lack of labor	10	13.3
4	lack of enough manure	8	10.7
5	Told to use only IF	2	2.7
6	Others	6	8.0
	Total	70	100

Key: IF= Inorganic Fertilizers

The reasons behind why farmers are not currently using manure on rice are depicted in Table 4. Majority (36%) of the respondent farmers do not use manure in rice production because they give first priority to other cereal crops such as sorghum, maize and finger millet; 22.7% of the respondents responded that they lack experience and knowhow on the use of manure on the production of rice. The remaining respondent farmers answered lack of labor (13.3%); lack of enough manure to be used (10.7) and 2.7% of the respondents responded that they are told by the extension workers to use inorganic fertilizer in rice production but no idea to use manure. Still 8% of the respondent farmers answered that they have many other reasons such as remoteness of the rice fields from their homesteads (Table 5).

4.4.1.2 Farmers' Perception of Inorganic Fertilizers (IF)

Table 5: Farmers' Perception of Inorganic Fertilizers (N=75)

Question	Response	Kebelle Name			Total	%
		Ts/kerni	Mezekir	M/alem		
Are you willing to take IF?	Yes	12	4	2	18	24
	No	21	19	17	57	76
	Total	33	23	19	75	100
If no Why?	I have enough manure	1	4	3	8	14
	My farmland is fertile	1	1	2	4	7
	IF deplete soil fertility	7	4	5	16	28.1
	IF have Burning effect	10	3	1	14	24.6
	IF need yearly appl.	2	5	4	11	19.3
	Others (lack of knowhow…)	0	2	2	4	7
	Total	21	19	17	57	100

N= Sample Size

According to the current study, majority (76%) of the farmers of the study wereda have no willingness in using inorganic fertilizers such as DAP and Urea (Table 5). The reasons are very much complex and vary

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among farmers. As is depicted in Table 5, 76% of the respondent farmers in the study kebeles do not have any willingness in using such external inputs. The farmers argued that they are very much keen in accepting a technology but only when it satisfies them in different ways. Among the 57 (76%) respondent farmers who showed no willingness in demanding inorganic fertilizers, 28.1% of them answered inorganic fertilizers deplete soil fertility i.e. inorganic fertilizers leave no residual nutrient for the next crop; 24.6% of them answered inorganic fertilizers have burning effect on crops; 19.3% answered inorganic fertilizers need yearly application at an increased rate; 14% answered they have enough manure; 7% of the respondents answered that their farmland is fertile and does not need any fertilizer and the remaining 7% of the respondents answered that they lack enough knowhow in using inorganic fertilizers properly. Kiros (2010) also concluded that fertilization may not be profitable when water is the limiting factor. Only 24% of the farmers showed willingness in using inorganic fertilizers and their direct justifications are because they don't have enough manure; otherwise inorganic fertilizers can never be compared with manure. Their other reasons were inorganic fertilizers boost productivity and are easy to handle.

4.4.1.3 Farmers' Economic perception of Inorganic Fertilizers (IF)

As Table 6 showed, majority of the farmers (94.7%) argued that the use of inorganic fertilizers is not economically feasible. These farmers who argued the economically infeasibility of inorganic fertilizers classify the infeasibility in to many crucial aspects.

Table 6 : Farmers' Economic view of Inorganic Fertilizers (N=75)

Question		Kebelle Name			Total	Percent
		Ts/kerni	Mezekir	M/alem		
Is use of IF economically Feasible?	Yes	3	1	0	4	5.3
	No	30	22	19	71	94.7
	Total	33	23	19	75	100
If not Why?	High price of IF	23	13	8	44	62
	Mkt price of crops is by far below IF	3	3	1	7	9.9
	Burning effect of IF minimize yield	2	2	3	7	9.9
	Forced to take IF and unwilling to pay back	1	4	6	11	15.5
	Increased price of IF	0	0	1	1	1.4
	Others (paying credit when crop price is low)	1	0	0	1	1.4
	Total	30	22	19	71	100

KEY: Mkt=market; IF=inorganic fertilizer; N= Sample Size

From the 71 farmers who answered use of DAP and Urea is not economically viable, 62% of them viewed the initial price of IF is higher. This agrees with the findings of Bagheri *et al.,* (2008) who found that the awareness of farmers regarding the use or no use of agricultural technologies is mostly confined with the visible impacts such as the direct economic gain. Other 9.9% answered the market price of crops grown using inorganic fertilizers is by far below the initial price of the inputs used and hence the sale of such crop yield is not enough to pay back the loan of the inorganic fertilizers. This agrees with the findings of Christopher (1994) who said, "The conventional wisdom is that the best way to improve the productivity of resource poor farmers is through the use of high-yielding variety of crops and chemical fertilizer, however, research evidences show that the resulting yield increases may not be sufficient to pay for these inputs". Again another 9.9% of the respondent farmers argued that inorganic fertilizers have burning effect on the crops being grown and hence minimize the final yield especially during years of low rainfall. Another 15.5% of the respondent farmers argued that they are taking inorganic fertilizer out of their will (even while they had enough manure) and so they don't use them properly but pay the price. This is so because the extension system didn't consider a great weight for the manure as that of the inorganic fertilizers and this is affecting the positive attitude they had for manure. Only 1.4% of the respondents claimed that DAP and Urea are not economically viable due to the fact that their price is ever increasing; and finally a small number of the respondents (1.4%) perceived that the loan for the inorganic fertilizers is paid when the market price for such crop is low (especially during the harvest time). The chi-square test for the economic view of the respondent farmers showed that there is no significant difference among the farmers of the three study villages with regard to the economic views of the farmers to inorganic fertilizers.

4.4.2 Farmers' Perception of Integrated use of FYM and Inorganic Fertilizers

The respondents' perceptions towards integrated use of organic and inorganic fertilizers in rice production showed that the respondents were fairly aware of the nutrient depletion impacts of applying inorganic fertilizers. Percent scores of the influence of manures on improving soil fertility indicated that the respondents had positive perceptions about it (Table 6). As percent scores show, majority of the respondents were in agreement with the application of FYM. Majority (61.3%) of the respondents disagreed (24%) and strongly disagreed (37.3%) the idea that rice yield could be increased only by increased use of chemical fertilizer, i.e. they do not perceived inorganic fertilizers as the best means to increase production at the present time. Most of them were against the idea of increased application of only inorganic fertilizers and did not believe the process would lead to long term increased productivity. 37.3% remained undecided. This result agrees with the findings of Bagheri *et al.* (2008) who concluded that in spite of farmers' positive perceptions about manure, agrochemicals as external inputs are substituting them. With regard to the idea that whether farmers' benefit could be increased by decreasing chemical fertilizer and using other options in the long run or not, majority (46.7%) of the respondent farmers agreed strongly, 12 % agreed and 41.3% remained undecided. Finally, the idea of the farmers with regard to the integrated use of organic and inorganic fertilizer up on rice production was assessed and 45.35 of the respondent farmers have agreed strongly, 22.7% simply agreed and the remaining 32% remained undecided.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The effects of combined application of farmyard manure along with inorganic fertilizer could be understood from the improvements made in soil chemical properties, crop productivity (yield) and socioeconomic dimensions. Gross economic analysis revealed that integrated use of organic and inorganic fertilizers recorded considerably higher net returns over the control treatment. The highest mean net return of birr 18867.24 per hectare was recorded for the plot that received 9t/ha FYM together with 75kg/ha of each DAP and Urea which is birr 7240 more than the net returns of the control. The second highest mean net benefit of birr 16301.81 per hectare was obtained from plots that received 6t/ha FYM and 75kg/ha recommended dose of inorganic fertilizers. But these all are not necessarily true when considering the MRR. From the agronomic point of view, it was apparent from the above results that 9 t/ha of FYM in conjunction with 75kg/ha of each DAP and Urea yielded better than the rest of the treatment combinations which is 44.4Ql/ha. However, considering the costs that vary (TVC) the dominance analysis showed that the higher agronomic yield did not brought highest profit. Therefore, based on the principles of dominance analysis, only four treatments (1, 9, 5 and 6) were considered for the final analysis of MRR. Here it is worth mentioning that the yields of treatments 2, 7, 10 and 11 are higher than those of treatment 5 (36.66Ql/ha), but the dominance analysis showed that the value of the increase in yield is not enough to compensate for the increase in costs (TVC) of these treatments. The highest MRR was recorded between treatments 1 and 9 which was 2018%. That is if farmers invested birr 175 in using 60 Ql/ha of FYM with no inorganic fertilizer, they could recover the 175 birr plus an addition of birr 3531.42 which is 20.18 times the cost incurred. The second highest MRR (for going from Treatment 9 to Treatment 5) was 2013% and the third MRR was 1356%. This MRR of 1356% (1.356 birr increase) is much less than the previous two. Therefore, according to the law of the dominance analysis, to improve farmers' incomes it is important to pay attention to net benefits, rather than the agronomic (physical) yields because higher yields do not necessarily mean high net benefit.

Finally, the social perceptions regarding the use of organic or inorganic fertilizers and their integrated use were also addressed. According to the respondent farmers, 98.7% of them use FYM for their general crop production. Majority of the respondent farmers do not use manure in rice production because they give first priority to other cereal crops. Mean scores of the influence of farmyard manures on improving soil fertility indicated that the respondents had positive perceptions about it and they give great weight for the manure. The open willingness of farmers to demand inorganic fertilizers is very much low. 76% of the respondent farmers showed no willingness to use external inputs. Finally issues regarding farmers' perception on integrated use of FYM and inorganic fertilizers were addressed. Majority of the respondents were in agreement with the application of FYM. With regard to the integrated use of organic and inorganic fertilizers on rice production 45.35 of the respondent farmers have agreed strongly.

Hence, it can be reasonably concluded that farmyard manure (FYM) could be used instead of inorganic fertilizers to get higher net economic benefit but due to their inaccessibility, integrating FYM along with inorganic fertilizers would be the best alternative. Combined use of FYM with inorganic fertilizers could save part of the money that would have been paid for the greater doses of the chemical fertilizer and is socially acceptable. Therefore, taking the findings of the present study into consideration, it may be concluded that the farmers at the Tselemti wereda may apply a combination of 9t/ha FYM and 75kg/ha inorganic fertilizer to improve their economic gain in rice cultivation. However, more such studies need to be conducted at various soil and agro-climatic conditions to generate more detailed information.

5.1 Recommendations

To improve farmers' income, it is important to pay attention to net benefits, rather than the agronomic (physical) yields because higher yields do not necessarily mean high net benefit. This is one year result. However, the capacity of FYM in leaving a significant residual nutrient effect on the succeeding crops needs further long-term research because nutrient is residually accumulated each year. Such studies need to be conducted at various soil and agro-climatic conditions to generate more reliable information. Any policy and program aimed at sustainable rice production has to give due attention and priority in training and mobilizing farmers that help in raising their perception level based on their own choices only.

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