Available at www.ijcasonline.com ISSN:2349 – 0594

International Journal of Modern Chemistry and Applied Science

International Journal of Modern Chemistry and Applied Science, 2017, 4(2),526-534

Effects of Integrated Nutrient Management on Performance of Rice in Kaffa and Benchi Maji zones, southwestern Ethiopia

Mitiku Woldesenbet[*1] and Getachew Mekonnen[2]

[1,2] *Mizan-Tepi University, Department of Plant Sciences, Post Box No: 260, Mizan Teferi, Ethiopia*

[*] *Corresponding author: Mitiku Woldesenbet*

Email: wesenbetmitiku@gmail.com

Abstract: Soil fertility management is one of the major problems causing yield reduction of rice in southwestern Ethiopia. A study was initiated in 2016 to supplement low rates of NP fertilizers with farmyard manure (FYM) to determine its effect on the yield of rice in Kaffa and Benchi Maji zones of southwestern, Ethiopia. Eleven treatments consisting of 2.5, 5, and 7.5 t ha^{-1} FYM combined with 25,50 and 75% of recommended NP fertilizers as well as 100% recommended NP fertilizer and absolute control which were applied in factorial arrangement in a randomized complete block design with three replications. The experiment was conducted at Gojeb in Kaffa Zone and at Kuja in Benchi Maji zone using NERICA-4 rice Variety. The FYM used for the experiment was well decomposed under shade and spot applied together with the P fertilizer at planting; N was applied in split form. Statistical analysis revealed that the NP fertilizers and FYM significantly (p < 0.05) increased grain yield at both locations. Interactions of FYM and NP fertilizer rates were significant ($p \leq 0.05$) at both locations. The application of 5 t ha^{-1} FYM in combination with 75% inorganic NP has increased grain yield by 75.51% and 13.51% at Kuja and by 77.96% and 17.76% at Gojeb over the control and the application of 100% recommended rate of NP fertilizers, respectively. Similarly, the economic evaluation indicated that the application of 5 t ha^{-1} FYM + 75% inorganic NP gave the highest net return which is 78311.34 Ethiopian Birr ha^{-1} at Gojeb and 67521.8 Ethiopian Birr ha^{-1} at Kuja. Hence, it can be concluded that, the use of combined application of FYM (5 t ha^{-1}) with 75% of recommended rates of inorganic NP in the study areas and other locations with similar agro-ecologies can significantly increase rice yield and provide high economic return.

Keywords: Economic return**,** farmyard manure, integrated nutrient management, NP fertilizers

1.Introduction

Cereal crops are mostly grasses cultivated for their edible grains. They are grown in greater quantities and provide more energy worldwide than any other type of crop. In developing countries like Ethiopia, grain constitutes the entire diet of poor people [1].

Rice is one of the important cereal crops in the world. The crop has two cultivated and 22 wild species. The cultivated species are *Oryza sativa* L., Asian origin, and *Oryza glaberrima* Steud, African origin. *Oryza sativa* is grown all over the world while *Oryza glaberrima* has been cultivated in West Africa for more than 3500 years [2]. Rice is normally a self pollinated crop although up to 3 percent natural crossing may occur depending on the cultivar and the environment [3].

Rice is by far the most economically important food crop in many developing countries, providing two thirds of calorie intake of more than 3 billion people in Asia, and one third of the calorie intake of nearly 1.5 billion people in Africa and Latin America [4]. Worldwide, rice is the second most important cereal crop after wheat. Most of the world's rice is cultivated and consumed in Asia, which constitutes more than half of the global population. Approximately 11% of the world arable land is planted annually to rice [5].

More than 2,000 million people, in Asia alone, obtain 60 to 70 percent of their calories from rice and its products [6].According to this fact sheet, it is also the most growing source of food in Africa, and is of noteworthy importance to food security in an increasing number of low income food deficit countries.

Rice was introduced and evaluated initially at different areas of Ethiopia such as Gambella, Pawe, and Fogera in the late 1960s. However, attention was not given to rice research prior mid 1990s. Since 1990, seven upland rice varieties including two NERICAs (New Rice for Africa) have been released. The average productivity of these varieties ranges from 2.5 to 4 t/ha on farmers fields [7]. Ethiopia has different rice agro-ecologies that can grow rain fed upland rice, rain fed lowland rice, and irrigated rice with a total potential land mass of 1 million hectare [8]. However, this yield is very low as compared to the world production due to different constraints among which soil fertility problem is the first.

Being in the tropics, most Ethiopian soils are very poor in their inherent soil fertility [9]. However, they were able to sustain crop production in the far past due to useful tradition soil fertility restoring practices such as fallowing, crop rotation, manuring, maintenance of forest cover, shifting cultivation so on [9]. The unlimited rise in population size is the core cause of the problem to satisfy the growing demand for more and more food and fuel led to continuous cropping, removal of crop residues to be used as energy source which otherwise been incorporated back in to the soil, forests were cleared aggravating soil erosion [10].

Population pressure has precluded fallow opportunities and resulted in continuous cultivation of the land, which consequently has led to the depletion of soil organic matter and nutrients. Intensive cropping systems based on cereal growing, intensive soil tillage, and removal of crop residues often lead to decreased level of soil organic matter, thereby adversely affecting soil physical and chemical properties.

The continuous use of fertilizers containing only few essential elements like those being used in Ethiopia, Urea and DAP, aggravate the depletion of other essential nutrients in soil [11], acidify soil [12] and have adverse effect on the environment and generally they are unsustainable. Reduced fertilizer use efficiency or recovery efficiency by crops is the most important problem associated with the use of chemical fertilizers. In developed country like USA, only 50% of the applied fertilizers are used by crops in the season. The situation is very severe in the tropics where only between 25 – 40% of the applied fertilizers is utilized by crops in the season. In the case of N-fertilizers leaching and denitrification are the main causes which reduce recovery efficiency. However, we cannot void the use of chemical fertilizers for crop production for the plenty of beneficial effect of these inputs [13].. Thus, there is need to mitigate the adverse effects of fertilizers and maximize the fertilizer use efficiency of crops.

Integrated application of organic and inorganic nutrients sources to soil is very crucial to counteract the negative aspects of chemical fertilizers. Organic nutrients that could be applied as biomass transfer, green manure, FYM, compost etc serve as source of nutrients for the growth and productivity of plants. In addition they help to increase organic matter content of the soil which in turn improves the physico-chemical characteristics of the soil notably, increase water holding capacity of the soil, CEC, and basic cations. They also improve the nutrient retention property of the soil, serve as reservoir of micronutrients and reduce leaching losses of nutrients ([14]; [15]). Besides these, they increase the fertilizer use efficiency of crops [13]. [16] stated that "both organic and inorganic inputs are necessary to enhance crop yields without deteriorating the soil resource base emphasizing the integrated application of both inputs for either of them are hardly available in sufficient quantities to small scale farmers and the multiple benefits of combined applications of organic and inorganic inputs". Therefore, this research was initiated with the following objectives.

- To determine the effect of integrated application of Farmyard Manure with NP fertilizers management on growth, yield components and yield of rice;
- To evaluate the economic feasibility of the integrated application of Farmyard Manure with NP fertilizers for rice production in the study areas

2. Materials and Methods

2.1. Description of the Study Site

The experiment was conducted in two locations namely, Ghimbo district Gojeb site in Kaffa zone and Guraferda district Kuja site in Benchi Maji Zone, Southwestern Ethiopia, during 2016 main cropping season. These sites were selected because of that they are the most potential areas of southwestern Ethiopia for rice production. The study sites at Gojeb and Kuja are located at 8° 06´ N, 36°2 9´ E, 1490 m.a.s.l. and 9° 07´ N, 37° 35´ E, 1238 m.a.s.l., respectively. The rainfall pattern of these areas is characterized by bimodal distribution with small rainy season *belg* (March-June) and main rainy season *meher* (July-November).

The soil physico chemical analysis of the study areas revealed that the soils of the experimental field were clay and clay loam in texture both at Gojeb and Kuja, respectively. The results also indicated that the soil of Gojeb and Kuja are moderately and slightly acidic with pH of 6.31 and 5.66, respectively. The soils have medium organic carbon (1.46) and total N (0.09%) at Kuja and low organic carbon (0.99) and total N (0.06%) at Gjebo. Available P is low both at Kuja (6.30 ppm) and Gojeb (5.90 ppm) (Table 1).

Table 1: Physico-chemical characteristics of soil of the experimental sites

Soil parameters	**Locations**	
	Kuja	Gojeb
Textural composition (%)		
Sand	22.00	16.30
Silt	25.00	24.80
Clay	53.00	58.90
Textural class	Clay	Clay
pH	5.66	6.31
Organic Carbon (%)	0.99	1.46
Total N (%)	0.06	0.09
Available P (mg kg^{-1})	5.90	6.30
CEC (cmol/kg)	16.22	23.41

2.2. Treatments and Experimental Design

The treatments that were considered in this study were

- ✓ 2.5 t/ha FYM + 25% of blanket recommended N and P_2O_5
- ✓ 2.5 t/ha FYM + 50% of blanket recommended N and P_2O_5
- ✓ 2.5 t/ha FYM + 75% of blanket recommended N and P_2O_5
- ✓ 5 t/ha FYM + 25% of blanket recommended N and P_2O_5
- ✓ 5 t/ha FYM + 50% of blanket recommended N and P_2O_5
- ✓ 5 t/ha FYM + 75% of blanket recommended N and P_2O_5
- ✓ 7.5 t/ha FYM + 25% of blanket recommended N and P_2O_5
- ✓ 7.5 t/ha FYM + 50% of blanket recommended N and P_2O_5
- ✓ 7.5 t/ha FYM + 75% of blanket recommended N and P_2O_5
- ✓ 100% blanket recommended fertilizer rate of N and P_2O_5
- ✓ Unfertilized plot (absolute control)

The treatments were laid out in randomized complete block design in factorial arrangement with three replications. Each block and plots with in block were spaced 1 m and 0.5 m apart, respectively. The plot size was 2.4 m x 3 m (7.2 m^2) with net plot size of 1.6 m x 2.6 m (4.16 m^2). The sources of N and P were urea (46% N) and Triple Super Phosphate (TSP, 46% P_2O_5), respectively. Each plot had 12 rows of 20 cm apart between them with seed rate of 100 kg ha^{-1}.The first row from each side served as border. In each plot, 0.2 m row lengths at the end of each row were left to be a border to avoid the border effect.

2.3. Experimental Procedures

Prior to planting, surface (0 - 30 cm) soil samples, from five spots across the experimental fields, were collected in a zigzag pattern, composited, and analyzed for soil physico-chemical properties and the results are depicted in Table 1.

Soil texture was determined using Bouyoucos hydrometer method [17]; soil pH was determined at 1:2.5 soils to water ratio by pH digital meter [18]; soil organic carbon was analyzed by wet digestion method [19] and total N by Kjeldhal method [20]. Available phosphorus was determined by the Olsen method [21]; the cation exchange capacity (CEC) using 1M-neutral ammonium acetate [20].

An improved variety of rice named as **NERICA-4** (WAB-450-IB-P-9/1), which is currently grown extensively by the model farmers in the study areas, was used as a test crop. The variety was released in 2006 by the Pawe Agricultural Research Center for its high yield and promising agronomic performances [22].

The rice seeds were sown in rows spaced 20 cm apart by hand drilling at the seed rate of 100 kg ha^{-1}. The sources of N and P were urea (46% N) and triple super phosphate (TSP, 46% P_2O_5), respectively. All P and half of the N fertilizer sources for the respective inorganic N and P_2O_5 treatments were applied at planting. The remaining half of the inorganic N fertilizer was applied at tillering stage by side drilling. Weeds were removed manually three times *i.e.* at early tillering, maximum tillering and booting stages. No insecticide or fungicide was applied as there was no serious incidence of insect pests or diseases. Harvesting was done manually using hand sickles. The harvested product was sun-dried to a constant weight and threshing and winnowing were done subsequently.

2.4. Data Collection

Days to heading were recorded when the ears or panicles were fully visible on 50% of the plants from each plot by visual observation and days to physiological maturity were recorded when 90% of the plants reached maturity in each plot, *i.e.* when grains were difficult to break with thumb nail. Number of productive tillers m^{-2} was counted from two random 1m X 1m areas (5 rows of 1m length) within the net plot area at physiological maturity and the average was recorded as number of productive tiller m^{-2}. Plant height (cm) was determined from measurements of 10 randomly pre-tagged mother shoots from ground level to the top of the spike excluding the awns at physiological maturity. Likewise, the spikes in the pre-tagged 10 plants were collected and the total grains were counted to record the number of grains per spike. Thousand grains were counted in each plot using electronic seed counter from a bulk of threshed grain and their weight was measured using a sensitive balance at harvest and the weight was adjusted to 12.5% moisture content.

The total aboveground dry biomass yield including straw and spikes of plants in a net plot area was measured using spring balance after sun drying to a constant weight. Then threshed and the grain yield per net plot was weighed and adjusted to 12.5% moisture content. Harvest index was calculated as the ratio of grain yield to total aboveground dry biomass and expressed in percentage.

2.5. Statistical Data Analysis

The agronomic data were subjected to analysis of variance (GLM procedure) using SAS software program version 9.2 [23]. Homogeneity of variances was evaluated using the F-test as described by [24] and since the F-test has showed heterogeneity of the variances of the two locations for most of the agronomic parameters, separate analysis was used for the two locations. The Fisher's protected least significant difference (LSD) test at 0.05 probability level was employed to separate treatment means where significant treatment differences existed.

2.6. Partial Budget Analysis

The partial budget analysis as described by [25] was done to determine the economic feasibility of the fertilizer application. It was calculated by taking into account the additional input cost (variable cost) involved and the gross returns obtained from different treatments. The variable cost also included the labor cost involved for harvesting, threshing and winnowing of the produce as this varied according to the yield obtained from a particular treatment. For determining gross returns, the prevailing local market price at the harvest of rice (18.00 and 19.50 Ethiopian Birr kg^{-1} at Gojeb and Kuja, respectively) was used for computation. The net returns were calculated by subtracting the cost of treatment from its gross returns, *i.e.* RNR = GR-VC where, RNR = Relative net returns, GR = Gross returns, and VC = Variable cost.

3. Results and Discussion

3.1. Phenological and growth parameters

There was no significant difference in the number of days to heading due to the application of different rates of farmyard manure (FYM) in combination with different rates of inorganic NP at Kuja. However, it was observed that the application of fertilizers slightly delayed days to heading as compared to no fertilizer application (Table 2).

On the other hand, there was significant difference on the days to heading due to the application of different fertilizer rates at Gojeb. The application of the highest rate of FYM (7.5 t ha^{-1}) with 75% NP fertilizer has resulted to the delayed days to heading though there was no significant difference with the application of 7.5 t FYM ha^{-1} with 50% inorganic NP fertilizer. The possible reason might be that higher rates of FYM allow longer period for vegetative growth and heading for the crop, provided better ground cover and less loss of water through evaporation for further growth and development [26]. This might also be attributed to the synergic effects of the fertilizers in stimulation of enhanced cell division, promoting cell growth and prolonging vegetative growth for a relatively longer period owing to ample supplies of macro nutrients and possibly other micronutrients. This is in contrast with the finding of [27] who reported that maize plants without fertilizer application achieved 50% tasselling in about 56 days while plants grown with fortified cow dung reached 50% tasseling significantly earlier.

It was observed that there was significant difference ($P \leq 0.05$) on day to 90% of maturity due to the application different rates of FYM with different rates of NP fertilizers both at Kuja and Gojeb, respectively. It was observed that the longest days to maturity (110.80) at Kuja and (104.16) at Gojeb were observed from the application of 7.5 t FYM ha^{-1} in combination with 75 and 50% NP fertilizer, respectively (Table 2). From this study, it was observed that rice plants that received no fertilizer matured earlier than those received fertilizer perhaps as a result of the physiological consequence of fertilizer deficiency, which lead to stunting and early completion of life cycle [28]. Consequently, the stunted leaves become chlorotic as the lack of nutrient limits the synthesis of protein and chlorophyll. Furthermore, lack of chlorophyll inhibits the capacity of plants to assimilate CO_2 and synthesize carbohydrates leading to poor and premature flowering and fruit formation with shortening of the growth cycle [29].

There was significant ($P < 0.05$) effect of combined application of farmyard manure with inorganic NP fertilizers on plant height both at Kuja and Gojeb. Results have shown that the application of 5 t ha^{-1} and 7.5 t ha^{-1} farmyard manure with 75% recommended NP at Kuja (111.76 cm) and the application of 7.5 t ha^{-1} farmyard manure with 75% recommended NP at Gojeb (114.07 cm) has resulted to the tallest plant height. While the shortest plants were obtained from the control at both locations (Table 2). It was observed that when the rate of farmyard manure increased from 2.5 to 7.5 tha^{-1} and NP rates increase from 25% to 75% both at Kuja and Gojeb, plant height increased. This might be due to that the mineral NP sources may have fulfilled the NP requirements of the rice at early growth stages while farmyard manure provided the crop with nutrients at later stages due to their slow release of nutrients.

Similarly [30] and [31] indicated that the use of FYM in conjunction with inorganic fertilizers has the advantage of increasing the nutrient storage capacity of the soil since FYM release nutrients through time. Also the result of this experiment is in agreement with the finding of [32] who reported that the use of increased rates of FYM and N increased plant height of wheat and the shortest plants were recorded from the control treatment. Similarly, [33] reported that plant height of spring barley increased with organic manure application as compared to inorganic fertilizer alone. [34] also reported that the use of organic manures in combination with mineral fertilizers increased plant height of crops more than the application of inorganic fertilizers alone. This might also be attributed to the role that FYM plays in promoting vegetative growth as FYM contains higher nutrient levels with continuous and slowly released nutrients such as organic carbon, total N and available P, K and micronutrients as well as microbial and enzyme activities that contributes for the increased height due to cell division [34].

Table 2. Days to 50% heading (Dh), days to 90% maturity (Dm) and plant height (Ph) (cm) of rice as influenced by integrated application of FYM and NP at Kuja and Gojeb, southwestern Ethiopia

Treatment*	Kuja			Gojeb		
	Dh	Dm	Ph	Dh	Dm	Ph
2.5 t FYM + 25% RDF	73.13	105.28^{bcd}	104.36^{de}	71.80^{cde}	99.83^{ab}	103.87^{ef}
2.5 t FYM + 50% RDF	73.23	105.35^{bcd}	106.73^{cd}	71.80^{cde}	100.83^{ab}	106.07^{def}
2.5 t FYM + 75% RDF	73.73	106.04^{bc}	110.10^{bc}	72.80^{bcd}	101.83^{ab}	110.57^{abc}
5 t FYM+25% RDF	73.73	106.18^{bc}	107.83^{a-d}	72.80^{bcd}	100.83^{ab}	104.77^{ef}
5 t FYM+50% RDF	73.73	106.24^{bc}	109.43^{abc}	72.80^{bcd}	101.83^{ab}	109.37^{bcd}
5 t FYM+75% RDF	74.43	108.08^{abc}	111.76^{a}	73.10^{b}	102.83^{ab}	111.77^{ab}
7.5 t FYM+25% RDF	74.43	108.08^{abc}	107.83^{a-d}	73.80^{b}	103.43^{ab}	110.07^{a-d}
7.5 t FYM+50% RDF	75.43	108.93^{b}	109.83^{abc}	75.90^{a}	104.16^{a}	112.77^{ab}
7.5 t FYM+75% RDF	75.73	110.80^{a}	111.76^{a}	76.10^{a}	104.06^{a}	114.07^{a}
100% RDF	73.13	104.27^{cd}	107.73^{bcd}	71.06^{de}	99.83^{ab}	108.03^{cde}
Control	72.76	101.27^{d}	101.60^{e}	70.76^{e}	99.43^{b}	102.73^{f}
LSD (5 %)	NS	4.52	3.97	1.88	4.44	4.38
CV (%)	3.40	2.51	2.17	1.52	2.57	2.38

Means followed by the same letter within a column are not significantly different at P = 0.05 level of significance; * FYM = Farmyard Manure in t ha^{-1}, RDF = Recommended Dose of inorganic NP Fertilizer

3.2. Yield components

It was also observed that there was significant ($P < 0.05$) effect of combined application of farmyard manure with inorganic NP fertilizers on the number of total and productive tillers m^{-2} both at Kuja and Gojeb. The combined application of farmyard manure with inorganic NP fertilizers has increased the number of total and productive tillers m^{-2} up to 5 t ha^{-1} and decreased when the rate raised to7.5 tha^{-1}

both at Kuja and Gojeb. As a result, the application of 5 t ha^{-1} FYM with 75% inorganic NP resulted in the highest number of total tillers m^{-2} of 205.33 and 247.6 and productive tillers m^{-2} of 194.6 and 232.3 at Kuja and Gojeb, respectively. This research has indicated that this treatment gave 76.65% and 65.86% increase of number of productive tillers m^{-2} over the control treatment at Kuja and Gojeb, respectively (Table 3). This might be due to the increased rate of FYM which might have increased the availability of NPK and improvement of soil water holding capacity that contributed for the massive generation of productive tillers.

Table 3. Number of total tillers (TT), productive tillers (PT) m^{-2} and thousand grain weight (TGW) of rice as influenced by the integrated nutrient management at Kuja and Gojeb, southwestern Ethiopia

Treatment*	Kuja			Gojeb		
	TT	PT	TGW (g)	TT	PT	TGW (g)
2.5 t FYM+25% RDF	169.3^{d}	168.6^{c}	36.1^{d}	200.7^{f}	193.0^{b}	43.0^{abc}
2.5 t FYM+50% RDF	177.0^{cd}	169.6^{c}	36.6^{cd}	202.4^{f}	198.6^{ab}	44.0^{ab}
2.5 t FYM+75% RDF	187.6^{bc}	171.6^{c}	36.9^{bcd}	215.2^{e}	212.4^{ab}	32.0^{c}
5 t FYM+25% RDF	194.3^{ab}	191.6^{ab}	38.9^{abc}	227.0^{cd}	222.0^{ab}	45.5^{a}
5 t FYM+50% RDF	202.0^{a}	194.3^{ab}	39.13^{ab}	236.7^{b}	210.0^{ab}	46.3^{a}
5 t FYM+75% RDF	205.33^{a}	194.6^{a}	39.26^{ab}	247.6^{a}	232.3^{a}	47.1^{a}
7.5 t FYM+ 25% RDF	204.3^{a}	189.0^{b}	38.8^{abc}	221.4^{cd}	195.3^{b}	43.6^{ab}
7.5 t FYM+ 50% RDF	202.0^{a}	189.3^{ab}	38.9^{abc}	229.4^{c}	211.3^{ab}	42.3^{abc}
7.5 t FYM + 75% RDF	202.6^{a}	189.3^{ab}	39.83^{a}	237.1^{b}	215.0^{ab}	41.8^{abc}
100% RDF	148.0^{e}	132.3^{d}	36.3^{d}	154.7^{g}	140.3^{c}	37.6^{abc}
Control	62.0^{f}	46.6^{e}	31.9^{e}	86.7^{h}	79.3^{d}	33.90^{bc}
LSD (5 %)	11.69	5.50	2.42	7.06	34.11	11.59
CV (%)	3.88	1.94	3.81	2.03	10.50	16.45

Means followed by the same letter within a column are not significantly different at P = 0.05 level of significance; * FYM = Farmyard Manure in t ha^{-1}, RDF = Recommended Dose of inorganic NP Fertilizer

[26] stated that at later crop growth stages, the mineralization of FYM coupled with increased doses of inorganic NP contributed to the increased number of productive tillers m^{-2} over the control of barley crop. The mineralization of FYM gradually releases essential nutrients over a period than the applied inorganic NP, hence reducing their leaching and improving the use efficiency of crop.

The result of this study also indicated that the highest thousand grain weight (39.83 g) at Kuja was obtained from the application of 7.5 t ha^{-1} FYM in combination with 75% of inorganic NP fertilizer. On the other hand, the application of 5 t FYM ha^{-1} in combination with 75% NP fertilizers has resulted to the highest thousand grain weight (47.1g) at Gojeb showing an advantage of 24.85% at Kuja and 38.93% at Gojeb, respectively, over the control (Table 3). The possible reason for the increased thousand grain weight could be that mineral fertilizer and mineralization of organic fertilizer sources throughout the growing period did not expose the plants to nutrient stress at any stage resulting in maximum grain filling. In agreement with these results, several workers ([36]; [37]; [38]) have reported significant increase in the number of thousand grain weight of wheat by applying farmyard manure and mineral fertilizer in combination as compared to inorganic fertilizer application alone.

The lowest thousand grain weight of 31.9 g at Kuja and 33.90 g at Gojeb were recorded from the control plots. This decrease in thousand grain weights could be due to shrivelled seeds with smaller size produced with no fertilizer application. This result was in agreement with the finding of [39] who reported that thousand grain weight of wheat was significantly increased with the use of recommended dose of inorganic NPK in combination with FYM. Similarly, [40] obtained the highest 1000 wheat grain weight, from the application of FYM in combination with inorganic NP while the lowest 1000 grain weight from no fertilizer application.

The highest number of grain $spike^{-1}$ (36.1) at Kuja and (40.5) at Gojeb were obtained when 5 t ha^{-1} FYM was applied in combination with 75% recommended rate of inorganic NP fertilizer (Table 4). The increase in number of grain $spike^{-1}$ when 5 t ha^{-1} FYM was applied with increased level (75%) of NP could be due to enhancement of plant growth and development as a result of FYM, nitrogen and phosphorus fertilizer application that might have promoted the plants to produce more number of fertile tillers. In agreement to this result, [41] reported significantly higher wheat number of grain $spike^{-1}$ with FYM (2.5 t ha^{-1}) + *Leucaena* biomass (2.5 t ha^{-1}) + 75% RDF than 100% recommended rate of inorganic NP fertilizer and attributed this to better availability of nutrients. In contrast to this result, [42] reported non-significant effect of organic fertilizers on thousand grain weight of rice.

3.3.Yields and harvest index

Straw and aboveground biomass yield were significantly (P<0.001) influenced by the combined application of farmyard manure and inorganic NP fertilizers both at Kuja and Gojeb. Accordingly, the application of 5 t ha^{-1} FYM in combination with 75% inorganic NP gave the highest biomass yield of 8831.8 and 10158.9 kg ha^{-1} at Kuja and Gojeb, respectively (Table 5).

Table 4. Number of grain spike^{-1} (NGS) and grain yield (kg ha^{-1}) of rice as influenced by integrated nutrient management at Kuja and Gojeb, southwestern Ethiopia

Treatment*	Kuja		Gojeb	
	NGS	Grain yield (kg ha^{-1})	NGS	Grain yield (kg ha^{-1})
2.5 t FYM+25% RDF	27.9^{b}	3577.3^{c}	30.5^{d}	3737.7^{c}
2.5 t FYM+50% RDF	28.2^{b}	3635.3^{c}	32.1^{d}	4200.2^{bc}
2.5 t FYM+75% RDF	28.7^{b}	3684.3^{bc}	36.9^{bc}	4455.1^{abc}
5 t FYM + 25% RDF	34.2^{a}	3924.3^{a}	38.6^{ab}	4685.2^{ab}
5 t FYM + 50% RDF	34.9^{a}	4018.0^{a}	39.7^{a}	4878.5^{ab}
5 t FYM + 75% RDF	36.1^{a}	4050.0^{a}	40.5^{a}	5064.2^{a}
7.5 t FYM+25% RDF	34.2^{a}	3911.0^{a}	36.5^{c}	4944.0^{ab}
7.5 t FYM+50% RDF	34.2^{a}	3904.0^{a}	36.7^{bc}	5000.4^{a}
7.5 t FYM+75% RDF	34.3^{a}	3886.3^{ab}	36.5^{c}	5003.2^{a}
100% RDF	29.7^{b}	3502.7^{c}	31.4^{d}	4164.7^{bc}
Control	26.9^{b}	1072.7^{d}	25.6^{e}	1116.1^{d}
LSD (5 %)	3.32	213.83	1.95	796.36
CV (%)	6.18	3.54	3.28	10.94

Means followed by the same letter within a column are not significantly different at P = 0.05 level of significance; * FYM = Farmyard Manure in t ha^{-1}, RDF = Recommended Dose of inorganic NP Fertilizer

It was observed that the combined application of farmyard manure and inorganic fertilizers have resulted in higher aboveground biomass yield than the application of 100% recommended rate of inorganic NP alone (Table 5). This implies that integrated use of farmyard manure and inorganic fertilizers responded better to increase productivity than the use of inorganic fertilizer alone in the study areas. Likewise, [43] suggested that by the use of mixed chemical and bio fertilizers not only production can be kept at optimum level, but also the amount of chemical fertilizer to be used can be reduced. Plant bio-chemical activities improve by absorption of nutrients from soil and this in turn increases the grain yield and biological yield plant^{-1}.

Table 5. Straw yield, above ground biomass yield (AGBY) and harvest index of rice as influenced by integrated nutrient management at Kuja and Gojeb, southwestern Ethiopia

Treatment*	Kuja			Gojeb		
	Straw yield (kg ha^{-1})	AGBY (kg ha^{-1})	Harvest index (%)	Straw yield (kg ha^{-1})	AGBY (kg ha^{-1})	Harvest index (%)
2.5 t FYM+25% RDF	4562.3^{ab}	8139.7^{cd}	43.9^{a}	4793.3^{a}	8531.0^{bc}	43.9^{c}
2.5 t FYM+50% RDF	4592.0^{ab}	8227.3^{bcd}	44.1^{a}	4579.2^{a}	8779.4^{abc}	47.8^{ab}
2.5 t FYM+75% RDF	4710.3^{ab}	8394.7^{abc}	43.8^{a}	4895.6^{a}	9350.8^{abc}	47.6^{b}
5 t FYM + 25% RDF	4731.3^{ab}	8655.7^{abc}	45.3^{a}	4807.5^{a}	9492.8^{abc}	49.3^{ab}
5 t FYM + 50% RDF	4753.0^{a}	8771.0^{ab}	45.7^{a}	5168.5^{a}	10047.0^{abc}	48.6^{ab}
5 t FYM + 75% RDF	4781.8^{a}	8831.8^{a}	45.8^{a}	5094.6^{a}	10158.9^{abc}	49.9^{a}
7.5 t FYM+25% RDF	4676.8^{ab}	8587.8^{abc}	45.5^{a}	5123.0^{a}	10066.9^{abc}	49.1^{ab}
7.5 t FYM+50% RDF	4693.4^{ab}	8597.4^{abc}	45.4^{a}	5191.3^{a}	10191.7^{a}	49.0^{ab}
7.5 t FYM+75% RDF	4688.2^{ab}	8574.5^{abc}	45.3^{a}	5182.2^{a}	10185.5^{ab}	49.1^{ab}
100% RDF	4229.3^{b}	7732.0^{d}	45.2^{a}	4352.2^{a}	8516.90^{c}	48.8^{ab}
Control	2456.4^{c}	3529.1^{e}	32.2^{b}	2187.2^{b}	3303.2^{d}	33.8^{c}
LSD (5 %)	516.68	552.68	5.53	902.93	1655.7	2.12
CV (%)	6.86	4.07	7.44	11.41	10.90	2.67

Means followed by the same letter within a column are not significantly different at P = 0.05 level of significance;
* FYM = Farmyard Manure in t ha^{-1}, RDF = Recommended Dose of inorganic NP Fertilizer

It was also observed that there was highly significant (P < 0.001) effect of combined application of organic and inorganic fertilizers on grain yield both at Kuja and Gojeb. The highest grain yields of 4050.00 kg ha^{-1} and 5064.20 kg ha^{-1} at Kuja and Gojeb, respectively, were obtained from the application of 5 t ha^{-1} FYM combined with 75% recommended inorganic NP followed by the application of 5 t ha^{-1} FYM with 50% recommended rate of inorganic NP (Table 4). Moreover, there was no significant yield difference in the application of 5 t ha^{-1} FYM in combination with 25, 50 and 75% inorganic NP at Kuja and with the application of 5 and 7.5 t ha^{-1} FYM in combination with 25, 50 and 75% inorganic NP at Gojeb.

The application of 5 t ha^{-1} FYM in combination with 75% inorganic NP has increased grain yield by 73.51% and 13.51% at Kuja and by 77.96% and 17.76% at Gojeb over the control and the application of 100% recommended rate of NP fertilizers, respectively (Table 4). The increase in yield of rice due to the integration of 5 t FYM ha^{-1} with 75% inorganic fertilizers over 100% of inorganic NP might be due to the addition of both macro and micro nutrients from the FYM, which indicates that even full rate of blanket inorganic NP was not adequate for rice production both at Kuja and Gojeb. Moreover, the improvement in soil moisture characteristics resulted from FYM incorporation might have increased the efficiency of mineral NP fertilizer. This result is in agreement with the finding of [44] who reported that the application of inorganic fertilizers (NP or NPK) with FYM gave a better yield of barley than the application of 100% inorganic fertilizers alone. This indicates that the application of FYM is more important than the application of inorganic fertilizers alone which might be attributed to the beneficial effects of FYM on the soil's physical, chemical and microbiological properties [45]. The increased yield due to the application of 5 t ha^{-1} FYM with the combination of 75% of inorganic NP in these areas could also be due to the balanced supply of essential nutrients from their integration.

It was observed that the grain yield of rice increased up to the application of 5 t FYM ha^{-1} combined with 75% NP fertilizer and start declining when the rate increased to 7.5 t FYM ha^{-1}. This implies that the application of 5 t FYM ha^{-1} is optimum as compared to the application of 5 t FYM ha^{-1} . From this study, it was also observed that the harvest index was significantly ($P < 0.01$) influenced by the combined application of organic and inorganic fertilizer sources both at Kuja and Gojeb. The highest harvest indices, *i.e.* 45.8% at Kuja and 49.9% at Gojeb were recorded with the application of 5 t ha^{-1} FYM + 75% inorganic NP. From this experiment, it was observed that the application of 5 t ha^{-1} with 75% recommended rate of inorganic NP has increased the harvest index of rice both at Kuja and Gojeb. The possible reason could be that the increased rate of FYM and inorganic NP might have increased the efficiency of the rice to partition more assimilation to the grain. Similarly, [46] indicated that the increased rate of either FYM or inorganic NP has increased the harvest index of rice.

3.4. Economic evaluation

The economic analysis revealed that the highest net returns of Birr 67521.8 ha^{-1} at Kuja and 78311.34 at Gojeb were obtained with the application of 5 t ha^{-1} FYM + 75% inorganic NP (Table 6).

Table 6. Results of partial budget analysis to estimate net benefit of integrated nutrient management on rice at Kuja, southwestern Ethiopia

Treatment *	Grain yield (kg ha^{-1})	Adjusted Yield (kg ha^{-1})	Gross return (ETB ha^{-1})	Total cost (ETB ha^{-1})	Net return (ETB ha^{-1})
2.5 t FYM+25% RDF	3577.3	3219.57	62781.62	3005.8	59775.82
2.5 t FYM+50% RDF	3635.3	3271.77	63799.52	3149.4	60650.12
2.5 t FYM+75% RDF	3684.3	3315.87	64659.47	3271.9	61387.57
5 t FYM + 25% RDF	3924.3	3531.87	68871.47	3322.3	65549.17
5 t FYM + 50% RDF	4018.0	3616.2	70515.9	3531.4	66984.5
5 t FYM + 75% RDF	4050.0	3645.0	71077.5	3555.7	**67521.8**
7.5 t FYM+25% RDF	3911.0	3519.9	68638.05	3822.8	64815.25
7.5 t FYM+50% RDF	3904.0	3513.6	68515.2	3999.8	64515.4
7.5 t FYM+75% RDF	3886.3	3497.67	68204.57	4056.5	64148.07
100% RDF	3502.7	3152.43	61472.39	3028.6	58443.79
Control	1072.7	965.43	18825.89	1201.8	17624.09

ETB= Ethiopian Birr and the local market price of rice at harvesting time at Kuja was 19.50 Birr/kg and gross return was the product of market price and adjusted grain yield; * FYM = Farmyard Manure in t ha^{-1}, RDF = Recommended Dose of inorganic NP Fertilizer

Similarly, [44] reported that the application of 46 kg N + 40 kg P + 20 t FYM ha^{-1} on barley gave the highest net return of 16200 Birr ha^{-1}. Thus, from the economic point of view, it was apparent that 5 t ha^{-1} FYM + 75% of inorganic NP were more profitable than the other treatments both at Kuja and Gojeb since the highest income were from these treatments as compared with the other treatments. The result of this study indicated that the application 5 t FYM ha^{-1} in combination with 75% NP inorganic fertilizer has resulted to the highest economic return which is almost four fold over the control. This indicates that the application of optimum rate of FYM (5 t ha^{-1}) is more productive and economical over the application of 7.5 t FYM ha^{-1}.

4. Conclusion

The result of this study indicated that the growth, yield and yield components of rice at both locations responded positively to integrated application of organic and inorganic fertilizers. From the range of treatments tested, the combined application of 5 and 7.5 t ha^{-1} FYM with 50 and 75% recommended rate of inorganic NP fertilizers gave the highest grain yields at both locations. The economic analysis indicated that the application of 5 t ha^{-1} FYM + 75%

inorganic NP fertilizer gave the highest net return (67521.8 Birr ha^{-1}) at Kuja and (78311.34 Birr ha^{-1}) at Gojeb. Depending on the economic feasibility of the results, it can be concluded that, the use of combined application of FYM (5 t ha^{-1}) with 75% of recommended rates of inorganic NP (17.25 kg N ha^{-1} and 34.5 kg P_2O_5 ha^{-1}) can significantly increase rice yield and provide high economic return at both locations . Since the results of this experiment were from one season at two locations, it needs further study.

Table 7. Results of partial budget analysis to estimate net benefit of integrated nutrient management on rice at Gojeb, southwestern Ethiopia

Treatment *	Grain yield (kg ha^{-1})	Adjusted Yield (kg ha^{-1})	Gross return (ETB ha^{-1})	Total cost (ETB ha^{-1})	Net return (ETB ha^{-1})
2.5 t FYM+25% RDF	3737.7	3363.93	60550.74	2844.6	57706.14
2.5 t FYM+50% RDF	4200.2	3780.18	68043.24	2977.6	65065.64
2.5 t FYM+75% RDF	4455.1	4009.59	72172.62	3052.9	69119.72
5 t FYM + 25% RDF	4685.2	4216.68	75900.24	3362.6	72537.64
5 t FYM + 50% RDF	4878.5	4390.65	79031.7	3436.1	75595.6
5 t FYM + 75% RDF	5064.2	4557.78	82040.04	3728.7	**78311.34**
7.5 t FYM+25% RDF	4944.0	4449.6	80092.8	3825.4	76267.4
7.5 t FYM+50% RDF	5000.4	4500.36	81006.48	3899.2	77107.28
7.5 t FYM+75% RDF	5003.2	4502.88	81051.84	3906.6	77145.24
100% RDF	4164.7	3748.23	67468.14	2906.4	64561.74
Control	1116.1	1004.49	18080.82	1307.4	16773.42

ETB= Ethiopian Birr and the local market price of rice at harvesting time at Gojeb was 18.00 Birr/kg and gross return was the product of market price and adjusted grain yield; * FYM = Farmyard Manure in t ha^{-1}, RDF = Recommended Dose of inorganic NP Fertilizer

5. Acknowledgement

The authors would like to appreciate and acknowledge the financial support from Mizan-Tepi University (MTU), Ethiopia, for undertaking this study..

6. References

1. MoARD (Ministry of Agriculture and Rural Development). Ethiopian Agricultural Portal, http:www.eap.gov.et/Agricultural-commodities/crops/cereals.asp. Accessed in April, 2010. 2009
2. IRRI. *Major Research in Upland Rice*, Los Banos, Philipines.pp-252. 2001
3. James R.welsh. Fundamentals of plant genetics and breeding Colorado State university pp.290, 1981
4. FAO, Harnessing Science and Technology for sustainable Rice-Based Production System. Rome, Italy, 13-14 Feb.2004, 2004.
5. Chakravarthi, K. and Naravaneni, R., *Africa Journal of Biotechnology,* 5 (9), 684-688, 2006
6. International Year of Rice,. Rice is life. Available at http://www.fao.Org/irc/default.htm. Accessed in April, 2017, 2004
7. Wolelaw Sendeku, Factors Determining Supply of Rice: A Study in Fogera District of Ethiopia. Msc.*Thesis, Haramaya University, School of Graduate Studies, Haramaya, Ethiopia*, 2005
8. Sewagegne Tariku, An over view of Rice Research in Ethiopia. Adet Agricultural Research Centre, 2005
9. Okalebo, J.R., Gathua, K.W. and Woomer, P.L.. *Laboratory Methods of Soil and Plant Analysis: A Working Manual, 2nd Ed*ition. TSBF-CIAT and SACRED Africa, Nairobi, Kenya, 2002
10. Tilahun Amede, Endrias Geta and Takele Belachew. Reversing the degradation of arable land in Ethiopian highlands, Managing Africa's soil. No. 23, IIED-London, 2007.
11. C. R. Rohde. *Soil Science Society of American Journal*, 53: 119-122, 1989.
12. Rowell, D. L.. Soil Science: Methods and Applications. Longman, Singapore,1994.
13. Lindqvist, A. K.. Managing Land : A Practical guidebook for development agents in Ethiopia. Technical Handbook No. 36. RELMA in ICRAF/ World Agro forestry Center, AG Printing & Publishing Ltd, Kenaya, Dubai, 2005
14. Ravishankar, H., Tekaligne, T. and Habtamu, Z. Sustainable approaches towards organic management and intensification in coffee soils of Ethiopia. Some suggestions. Pp. 69-74. In: Wodimagegne Chekol and Engida Mersha (eds.) proceedings of the Fifth Conference of Ethiopian Society of Soil Sciences, March 30-31, Addis Ababa, Ethiopia, 2002.
15. Vanlauwe, B., J. Diels, N. Sanginga and R. Merckx.. *Plant and Soil* Sciences, 273: 337-354, 2005
16. CIAT-TSBF, Output 1. Biophysical and socioeconomic constraints to integrated soil fertility management (ISMF) identified and knowledge on soil process improved. Pp. 42 66. Challenge program- Biological nitrogen fixation: Position paper presented CIAT-TSBF working group for International Workshop on Biological Nitrogen Fixation for increased crop productivity, E*nhanced Human Health and Sustained soil fertility,* 10-14, Montpellier, France, 2002
17. Bouyoucous, C.J.. *Agronomy Journal*, 43: 434-438, 1951.
18. Page, A.L.. Methods of Soil Analysis. Part II. Chemical and Microbiological Properties. Madison, USA, 1982.
19. Walkley, A. and Black, C.A.. *Journal of Soil Science*, 37: 29-38, 1954.

20. Jackson, M. L.. *Soil* Chemical Analysis. Prentice Hall Grice. Englewood Cliffs, USA, 1973.
21. Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L.A. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *USDA* pp. 939, 1954.
22. MoARD (Ministry of Agriculture and Rural Development). Crop Development Department of Crop Variety Register. Issue No. 10. Addis Ababa, Ethiopia, 2007.
23. SAS (Statistical Analysis System) Institute. "SAS Version 9. 1.2 © 2002-2003". *SAS Institute*, Inc., Cary, North Carolina, USA, 2003.
24. Gomez, K.A. and Gomez, A.A.. S*tatistical Procedures for Agricultural Research, 2nd Edition*, John Wiley and Sons Inc. Toronto, 1984
25. CIMMYT (International Maize and Wheat improvement Center). *From Agronomic Data to Farmers Recommendations*: *Economics Training Manual. Completely Revised Ed*ition. CIMMYT, Mexico. D.F., 1988
26. Mitiku Woldesenbet and Tamado Tana,. *Journal of Science and Sustainable Development (JSSD)* 4(2), 21-39, 2016.
27. Ayoola, O.T. and Makinde, E.A. *African Journal of Food, Agriculture, Nutrition and Development*, 10 (3): 3-14, 2010.
28. Dudal, R. Forty years of Soil Fertility work in Sub-Saharan Africa. Integrated Plant Nutrient Management in Sub-Saharan Africa. CAB International, Wallingford, 2002
29. FAO (Food and Agricultural Organization). Fertilizer and plant nutrition bulletin: Guide to laboratory establishment for plant nutrient analysis. FAO, Rome, Italy, 2008.
30. Kumwenda, J.D., Waddingt, S.R., Snapp, S.S., Jones, R.B. and Malcolm, B.. Soil fertility management for the smallholder maize-based cropping system of Southern Africa: *A Review. Network research Working Paper Number 1*. Soil fertility network for maize-based cropping systems in countries of Southern Africa. CIMMYT, 1995
31. Mitiku Woldesenbet, Tamado Tana, Singh T.N, and Teferi Mekonnen. *Science, Technology and Arts Research Journal* 3(2): 34-42, 2014
32. Amanuliah, J. and Maimoona, N. *African Crop Science*, 8: 37-40, 2007.
33. f

    osu, A.J. and Leitch, M. *Australian Journal of Crop Science*, 3(1): 13-19, 2009.
34. Getachew Angachew.. Ameliorating effects of organic and inorganic fertilizers on crop productivity and soil properties on reddish-brown soils. pp. 127-150. *In: Proceeding of the tenth Conference of the Ethiopian Society of Soil Science*. 25-27, 2009.
35. Yassen, A., Khaled, A., Sahar, S.M. and Zaghloul, M.. *Journal of American Science*, 6(12): 858-864, 2010.
36. Singh, R. and Agarwal, S.K.. *Indian Journal of Agronomy*, 46(3): 462-467, 2001.
37. Iqbal, A.S., Abbasi, M.K. and Rasool, G.. *Pakistan Journal of Soil Sciences*, 21: 79-86, 2002.
38. Arif, M., Ali, S., Khan, A., Jan, T. and Akbar, M. *Sarhad Journal of Agriculture*, 22(1): 27-29, 2006.
39. Rasool, R., Kukal, S.S. and Hira, G.S. *Soil and Tillage Research*, 101: 31-36, 2008.
40. Saidu, A., Ole, K. and Leye, B.O. *International Journal of Science and Nature*, 5(4): 532-537, 2012.
41. Mehta, S.. Integrated nutrient management in wheat (*Triticum aestivum* L.) under irrigated condition. *Madrass Agricultural Journal*, 92(9): 535-539, 2005.
42. Oo, A.N., Banterng, A., Polthanee, A. and Trelo-Ges, V.. *Asian Journal of Plant Science*s, 9 (7): 414-422, 2010.
43. Shata, S.M., Mahmoud, A. and Siam, S.. *Research Journal of Agriculture and Biological Sciences*, 3(6): 733-739, 2007.
44. Abay Ayalew and Tesfaye Dejene. *Innovative Systems Design and Engineering*, 22(1): 25-34, 2012.
45. Chong, R.S.. Using organic fertilizers: Food and Fertilizer Technology Center, Taiwan.CIAT (2006). Improving fertilizer efficiency and developing soil and water management practices. Integrated Soil Fertility Management, TSBF-CIAT's Achievements and Reflections, 2002-2005, 2005.
46. Mooleki, S.P., Schoenau, J.J., Charles, J.L. and Gwen, G.. *Canadian Journal of Soil Science*, 84: 199-210, 2004.