RESPONSE OF RICETO DIFFERENT LEVELS OF NITROGEN AND SEED RATE AT GOJEB, SOUTHWESTERN ETHIOPIA

Msc Thesis

By

Nibras Nazib Aliye

October, 2018

Jimma, Ethiopia

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A Thesis

Submitted to the *Department of Horticulture and Plant Sciences, School of Graduate Studies, College of Agriculture and Veterinary Medicine, Jimma University, for the Partial fulfillment of the Degree of Master of Science in Agronomy*

Major Advisor: Adugnaw Mintesnot (Ph.D)
Co- Advisor: Merkeb Getachew (MSc Assistant professor)

October, 2018
Jimma, Ethiopia

DEDICATION

I Dedicated This Thesis to my Mother Wosila Nursebo and my wife Keyrat Hamdala

STATEMENT OF AUTHOR

First, I declare that this thesis is my original work and that all sources of material used for this thesis have been appropriately acknowledged. This thesis has been submitted in partial fulfillment of the requirements of M.Sc. Degree at Jimma University, College of Agriculture and Veterinary Medicine and is deposited at the University Library to be made available to users under rules of the Library. I seriously declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief references from this thesis are allowable without special permission, provided that accurate acknowledgment of the source is made. Requests for permission for extended reference from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the School of Graduate Studies when in his or her judgment the proposed use of the material is of scholarly interest.

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BIOGRAPHICAL SKETCH

The author Nibras Nazib Aliye, was born on 03 September 1983 at Dalocha district Silte Zone Southern Nation Nationality and People Region(SNNPR).He attended his Elementary and Secondary school at Dalocha Elementary and Secondary High Schools (1999-2000 and 2001-2002E.C), respectively. He joined Wolaita Sodo University in 2003 and graduated with the Degree of Bachelor of Science in the Plant Science in June, 2005. After graduation, he was employed by South Agricultural Research Institute (SARI) as researcher in the field of agronomy at Bonga Center and served for two years until he joined the school of graduate studies of Jimma University College of Agriculture and Veterinary Medicine in September 2016 to pursue a study leading to the Degree of Master of Science in Agronomy.

ACKNOWLEGEMENTS

I would like to express my heartfelt thanks to my major advisor Dr. Adugnaw Mintesnot and Co-Advisor Mr. Merkeb Getachew for their valuable advice, insight, and guidance starting from proposal development to the completion of the research work. I would like to extend my sincere gratitude to South Agricultural Research Institute (SARI) for giving the chance to pursue my post-graduate study. I am also grateful to Jima Agricultural Research Center for their particular help in soil and plant tissue analyses in their respective laboratories. I would like to express my sincere gratitude to my wife Keyrat Hamdala for her dedication and strong support throughout my study. I express my heartfelt gratitude to my family for their encouragement during the study period. I am grateful to my mother Wosila Nurseb. Above all, I would like to thank my God for giving me the health, peace and directing me with his true spirit all the time with success.

LIST OF ACRONYMS AND ABBREVIATIONS

ANUE	Agronomic N Use Efficiency
ARE %	Apparent Recovery Efficiency (ARE %)
CSA	Central Statistical Agency
CYMMYT	International Maize and Wheat Improvement Center
EIAR	Ethiopian Institute of Agricultural Research
EUCORD	European Cooperative for Rural Development
GWAO	Gimbo Woreda Agricultural Office
IPNI	International Plant Nutrition Institute
IRRI	International Rice Research Institute
MoA	Ministry of Agriculture
MoARD	Ministry of Agriculture and Rural Development
NRRDS	National Rice Research and Development Strategy of Ethiopia
PARC	Pawi Agricultural research center
PNUE	Physiological N Use Efficiency
SNNPR	Southern Nations and Nationalities and Peoples Regional State

TABLE OF CONTENTS

Contents **Page**

LIST OF TABLES

LIST OF APPENDICES

Appendixes **Page**

ABSTRACT

Rice (Oryza sativa L.) is increasingly becoming an important food and cash crop in Ethiopia, especially among small-scale farmers. However, its productivity is challenged due to lack of appropriate agronomic practices and recommendations. Especially, uses of appropriate N fertilizer and seed rates most importantly affect the productivity of rice increasing the cost of production in subsistence farming. Thus, a field experiment was conducted at Gojeb, Gimbo district in kaffa zone, southwestern Ethiopia during 2017 main cropping season with the objective of determining optimum of N level and seed rate application. The experiment was laid out in randomized complete block design in a factorial arrangement replicated three times. The treatments consisted of five nitrogen rates (0, 32, 64, 96 ad 128 kg N ha^{-1}) and three seed rates (50,60 and70kg ha^{-1}). The analysis of variance revealed that nitrogen rate highly significantly ($p<0.01$) affected all of parameters studied .Similarly, the interaction between nitrogen level and seed rate also highly significantly ($p<0.01$) affected total tillers and effective tillers, filled grain per panicle, panicle length and grain yield. Nitrogen concentration, uptake and N-use efficiency parametrs were significantly affected by the interaction effect. Highest number of effective tillers (357.33) persquare meter, numbers of filled grain per panicle (102) and grain yield (4755.2kg/ha) were recorded at 96kNha $^{-1}$ with 70kg ha $^{-1}$of seed. Similarly, highest total and straw N-uptake as well as gran N-content were recorded from 128kgNha^{-1} and 70kgha^{-1} from 96 kgNha^{-1}and70kgha^{-1}.The highest ANUE(23.63 and 22.37*) was recorded from 64and 96kgNha^{-1}with 70kgha^{-1} seed rate.The highest PNUE (138.75 and 135.65) as well as ARE% (93.50) was recorded. Therefore, increasing nitrogen rate and seedrate to optimume range 96kgN ha^{-1}and 70kgha^{-1} seed rate increased grain yield and yield component of rice. The correlation analysis also indicated that there was positive and highly significant association between grain yield and yield components and N uptake at maturity. The Partial budget analysis showed that highest net benefit and marginal rate of return was obtained at 64kgN ha^{-1}and70kg ha^{-1}seed.Hence 64kgN ha^{-1}and70kg/ha can be recommended in the study area. However, repeating the experiment over years by increasing the N level would help to draw sound recommendation.*

***Keyword**: Nitrogen rate, Seed rate, cash crop, N use efficiency*

1. INTRODUCTION

Rice is the most important and widely cultivated crop in the world. It is an essential food crop and a major food grain for more than half of the world's population (Liu *et al.,* 2013). It is a cereal crop, has been gathered, consumed and cultivated by many people worldwide for more than 10,000 years longer than any other crop (Onyango, 2014). It is a staple food for most of the Asian countries and widely cultivated all over the world, not only in Asia but also in America, Europe, Australia and Africa (FAO, 2016).In 2013, the area under the production of rice globally was 164.7 million hectares and the total production was about 745.7 million tons. The world average yield for rice was 4.5t ha^{-1} in 2013 (FAO, 2015).Even though it is cultivated the worldwide, more than 90% of this rice is consumed in Asia (IRRI, 2016). Asia is the home of rice as more than two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products (Rekha *et al*., 2015).

After maize, rice has the second-highest global production and as such it is considered as the most significant grain crop with regard to human nutrition and caloric intake, providing more than 5th of the calories consumed globally by the human species (Wagan *et al*., 2015).It provides 20% of the world's dietary energy supply, while wheat supplies 19% and maize 5% (Singh and Yadav, 2014).In Africa, rice production is mainly concentrated in North and West Africa. The two regions constituted about 73% of the total rice production in Africa in 2013.The area under the production of rice in Africa was 10.9 million hectares and a total production of 29.3 million tons in 2013 (FAO, 2015).In the last decade, rice has become the most speedily increasing food source in sub-Saharan Africa (Onyango, 2014).Certainly, due to population growth (4% per annum), increasing incomes and consumer desire in favor of rice especially in urban areas.The comparative growth in demand for rice is faster in this region than anywhere in the world (Conteh *et al*., 2012).

In Ethiopia, rice is a recently introduced crop and its area and production have been increasing over years.Rice is now becoming the most important cereal crops grown as food crop in different parts of Ethiopia.The country is characterized with immense potential for growing the crop. The cultivation of rice in Ethiopia is more recent history than its utilization as a food crop.Some evidence indicates that it was first started at the Fogera and Gambella plains in the early 1970s

(Mulugeta, 2006). It is currently considered as a strategic food security crop and its use as a food crop,income source,employment opportunity and animal feed has been well recognized in Ethiopia (Teshome and Dawit, 2011).It is reported that the potential rice production area in Ethiopia is estimated to be about 5.4 million hectares (NRRDS, 2009).Taking into consideration the importance and potential use of the crop, it has been recognized by the Government as "the new millennium crop of Ethiopia"as it is expected to contribute greatly towards ensuring household as well as national food security in the country (MoA, 2010).

In Ethiopia,the trend in the number of rice producing farmers,area allocated and production shows high increase rate especially since 2000.The number of farmers engaged in rice production has increased from 53 thousand in 2006 to 285 thousand in 2009 (NRRDSE, 2010). Similarly, the area allocated has increased from 8,364.84 ha in 2001 to 46,823.22 ha in 2014/15 along with production increase from 154, 12.04 tons in 2001 to 1,318,218.53 tons in 2014/15 (CSA, 2015).In the country, rice is cultivated on an area of about 0.454 million hectares in 2015/2016 and its productivity is 2.7 tons per hectare (CSA, 2016). Nearly all the rice varieties grown until recently in Ethiopia were the Asian types that have poor adaptation to upland conditions (MoARD, 2010). However, to meet the vast potential of the upland environment to grow rice, the upland rice variety "New Rice for Africa"(NERICA) has been recently introduced and grown in the different parts of the country (Zenna *et al*., 2008).

NERICA is derived from the crossing of the African rice (*O. glaberrima*) and the Asian rice (*O. sativa*), and possess high yielding potential, early vigor, non-shattering grains, good response to fertilizer applications, short growth cycle, tolerant to drought, and resistant to pests and disease (WARDA,2001) and most suitable in altitude below 1500 m.a.s.l (Mulugeta *et al*.,2011).Farmers in different parts of the country have shown intense interest in rice production and are frequently requested for improved rice technologies.In the country,rice has become one of the most important crops whereby its production and area coverage increase every year. However, there is a wide productivity difference between Ethiopia (3tha^{-1}) and other countries such as China (6.05t ha^{-1}); Japan (6.21t ha^{-1}) and South Korea (6.99t ha^{-1}) in terms of average yield (Tesfaye *et al.*, 2005) and in African country such as in Kenya which is 2.2 to 4.3 tons per hectare as reported by Atera *et al*. (2011) and Kega and Maingu (2011).Low rice productivity in Ethiopia is attributed to a shortage of high yielding varieties,terminal water deficit, low soil fertility and environmental fluctuations (MoA, 2010).

Nitrogen (N) is an essential nutrient and is often the most yield-limiting nutrient in rice production around the world (Samonte *et al*., 2006).It plays a key role in rice production as it is required in huge amount. According to Manzoor *et al.*(2006) and Li *et al*. (2012) rice grain yield were significantly increased with increasing nitrogen fertilizer application rate. In addition, grain yield of rice is responsive to N supply because N nutrition increase leaf area index (Anwar *et al*., 2011).Thus, both vegetative and reproductive phases of growth are highly dependent on adequate N supply.The best dose of mineral fertilizer is the one which gives maximum economic return at minimum cost (Ananthi *et al*.,2010).The rate of nitrogen is critical in terms of their impacts on yield contributing parameters as nitrogen increases plant height,leaf size, the number of panicles, the number of spikelets and filled spikelets per panicle (Shakouri *et al*., 2012).

Therefore, nitrogen supply must be available according to the needs of the plant for optimal yield (Azarpour *et al*., 2011). Because nitrogen fertilizers are highly soluble and once applied to the soil may be lost from the soil-plant system or becomes unavailable to the plants due to the processes of leaching, NH_3 volatilization, denitrification and immobilization. Among various nutrients, nitrogen had the strongest influence on growth of rice (Ahmed *et al.*, 2005). Shiferaw *et al*. (2012) reported that 92 kg N ha^{-1} increased grain yield of rain-fed rice from 3540 to 5900 kg ha^{-1}in Gambella.There are several reports showing the yield increase of rice crop grown in different rice ecologies due to applied nitrogen fertilizer (De Datta and Patrick, 1986; Patra *et al*., 1992; Zewdie, 2004; Sewenet, 2005)..

Various research findings indicate that rice responses vary with rate of nitrogen at various locations. According to Sewenet (2005) application of 23 kg, N/ha recommended at the Fogera plains Vertisols for profitable grain yield of rice had significantly improved grain yield (3992 kgha^{-1}). Similarly, Bekele and Getahun (2016) recommended at 46 kg N to improve the grain yield and yield component of rice on nitosols at kamashi zone under rainfed conditions.Despite the areas huge rice production potential, declining soil fertility is affected rice production and productivity. This is due to the farmer’s cropping system such as mono cropping, continues cultivation, overgrazing, and removal of crop residue. In addition, the environmental condition of the area has also a great impact on soil fertility. Despite the above-mentioned importance and coverage of an area, its productivity is very low.Rice production could be affected by several factors including climate, physical conditions of the soil, soil fertility, water management, sowing date,cultivar,seed rate,weed control practices,and fertilization(Angus *et al.*,1994;Jing *et al.*,2008). In rice growing area, losses of nitrogen could occur through leaching, volatilization, denitrification, and immobilization, as a result N use efficiency and yield of the crop reduce.

The mutual competition among plants at high seed rate decreased the grains per panicle (Angiras and Sharma, 2000) .Excessive plant population densities can lead to increase plant height and weaker culms, increasing the potential for losses due to lodging and disease (Dofing and Knight, 1994). Adopting optimum seed rate is one of the most important agronomic practices for maximum yield of the crop.If high seed rate is used, plant population will be more and there will be competition among plants for growth factors resulting in low quality and low yield. On the other hand, if low seed rate is used, yield will be low (Hamida *et al.*, 2002).Delessa (2007) reported that higher grain yield of rain fed rice crop was obtained at the rate of 100 kg ha^{-1}. Sewenet (2005) reported that a seed rate of 120kg ha^{-1}was found to produce higher yield under rain fed conditions.

In addition to this, Merkine (2016) reported that application of 46kg/haN in two equal split (50% after establishment of seedling and the remining 50% at panicle inition)improved the grain yield and yield component of upland rice (NERICA 4) on nitosols under rain feed condition in kaffa zone Gimbo district.Many studies reported that the nitrogen level and the seed rates determine the growth of cereal crops and modify their characters (Cheema *et al.,*2002; Sewenet,2005;Assefa and Yemane; 2014,Shayanbekova *et al.,*2015).Universal fertilizer rate and planting density at all sites may not be applied because of variations in weather and soil type (Azam-Ali and Squire,2002).Thus, location specific recommendation of nitrogen and seed rates has vital role on yield and quality of rice.Some of the factors contributing to low yield of rice are:lack of high yielding cultivars, lodging, weed infestation, water logging, low moisture and fertility conditions (Taddesse,2009).

Suitable climatic and edaphic conditions of Gojeb area create a conducive environment for rice cultivation and this crop offers good scope for diversification of the existing cash crops and cereal-based cropping system of the area.Even though rice is one of widely produced cereal in Gojeb area its production is not satisfactory due to blanket recommendation of seed rate and N fertilizer level without considering specific soil types and agro-ecological characteristics of the area.In addition,different varieties of rice have different tillering capacity which compete for available resource .In view of this evidence, it is necessary to find appropriate nitrogen level and seed rate to increase yield of rice in the study area.Hence, this study was initiated with the following general Objectives:

- To determine optimum rate of nitrogen and seed rate for yield of rice at Gojeb Agro-ecological condition, southwestern Ethiopia.

- To assess N use efficiency of rice under different nitrogen and seed rate.

2. LITERATURE REVIEW

2.1 Botanical Description and Ecological Requirements of Rice

The genus *Oryza* (meaning oriental) belongs to the sub-tribe *Oryzineae*, tribe *Oryzeae* and family *Poaceae*. The tribe *Oryzeae* is an isolated group in the family *Poaceae* and is characterized by an aquatic mode of life.There are 27 species of *Oryza* till date.Of these, only two species, namely *O. sativa* L. and *O. glaberrima* Steud, are cultivated and come under the section"*sativa*" (DHAOGTR,2005 ;Moreshita,1984;Onwueme and Sinha,1999).The chromosome number of these species is 2n = 4x = 24. From ancestral forms in west Africa and south and southeast Asia, the two cultigens (cultivated species) evolved separately and became known as African rice (*O. glaberrima* Steud*)* and Asian or common rice (*O. sativa*), respectively.*O. sativa* is, the main species of rice cultivated widely throughout the world. It is believed to have originated from the wild species O.perennis and is divided into three sub-species, viz. Japonica, Indica and Javanica (Moreshita, 1984).

These sub-species are also considered as geographical races.Hybrids between them show varying degrees of sterility.According to WARDA (2008) and Mulugeta *et al*.(2011)New Rice for Africa (NERICA) is derived from the crossing of the African rice (*O. glaberrima* Steud) and the Asian rice (*O. sativa* L.) and possess high yield potential,early vigour, short growth cycle, tolerant to abiotic stresses such as drought, resistance to blast and yellow mottle virus, good response to fertilizer, good grain qualities, non-shattering grain and hold up to 400 grains per panicle compared to 75 to 100 grains of its African parents (Aredo *et al*., 2008).Although rice has been cultivated for many years, its origin has always been a matter of controversy. Botanists base their evidence largely on the habitats of the wild species.

It is presumed that the cultivated species of rice have been developed from certain wild race and the general consensus of opinions is that rice was domesticated in India, probably the coastal area of eastern India. The longer the group is established in an area, the larger will be the number of species to be found there.Rice is a unique food crop because it is adapted to grow under flooded submerged conditions in vast areas of flat, low-lying tropical soils during the rainy season. This is because it possesses aerenchymatic cellular structures in its leaves, stem and roots, which permit air to diffuse from the leaves to root surfaces providing the submerged roots with sufficient oxygen for normal respiration and nutrient absorption. Although the highest yield of rice is obtained with controlled water depth, rice can also be grown under upland conditions without flooding. Rice is hydrophytes and often cultivated in the lowlands as a semi-aquatic crop inundated with variable depths of water for a period, which may extend to cover the whole of its life cycle (Chang, 1989; IRRI, 1993; Onwueme and Sinha, 1999).

Some varieties can tolerate water depth even up to several meters. Flood-prone lowlands include deep-water (to a depth of 1m) and floating rice(water depth extending from1-6m).Rain fed lowland rice grows in bounded fields that are flooded for at least part of the cropping season to water depths, which do not exceed 50 cm for more than 10 consecutive days. However, varieties and strains of rice, which are grown under dry rain fed, semi-dry conditions of the uplands, unbounded flat or slopping fields, solely by rainwater or with supplemental irrigation. Higher silicon content in rice hulls and the relatively lower content in leaves and stems enhance the plant ability to resist several insects and diseases (De Datta and Patrick, 1986).Rice production systems differ widely in their cropping intensity and yield ranging from single crop rain fed lowland and upland rice. Rice requires a hot and high humid climate. High altitude and low temperature delay its flowering and maturity.

Temperature ranging from 21^{0}C to 35^{0}C throughout the life cycle is conducive to its growth and development (De atta and Patrick, 1986).Except Antarctica, every continent in the world produces rice. Rice grows from the equator to latitudes of 53^{0}N (in China) and 40^{0}S and to elevations (in tropical regins) as high as 3000 meter above sea level. The total area under rice cultivation is globally estimated to be 163 million hectare with annual production averaging 730.2 million metric tons (FAO,2013).More than half of the world's population depended on rice as its major daily source of calories and protein,each consuming from 100 to 200 kg of rice per year (Wilfred,2006).Rice grows successfully in avariety of soils.The most important requirement of soil is its ability to hold moisture for a considerable period and sustain a good rice crop.Alluvial soil with impervious sub-soil is ideal for rice. Rice will grow well over a relatively wide pH range of 5 to 7.5, although the best soil is slightly acidic pH of 5.5 to 6.6 (Street *et al.*, 2003).To a large extent, its tolerance to soil pH and ability to grow in submerged soil and the fact lies that under water-logged submerged conditions, the pH of acid soils increases and that of alkaline soil decreases. Some varieties of rice evolved through natural seection by farmers over ages and rice scientists also breed a number of rice varieties that are tolerant to soil salinity and to some other adverse soil conditions such as phosphorus and zinc deficiency and iron toxicity (De Datta and Patrick,1986).Currently,upland and flood-prone rice account about 80% of the global rice supply and it is unlikely that production from this system can be significantly increased in the near future (Doberman and Fairhurst,2000).Any further increase in the optimum temperature especially during reproductive stages may cause significant yield and yield component losses. Due to this reason temperature below 15°C can cause serious damage to the growth and development of the crop (Krishnan *et al*., 2011).Correspondingly Zhang *et al*.(2013) also reported that high temperature during night time has serious effects on the tillering and spikelet fertility which, in turn, decreases the total biomass production and grain yield. On the other hand, since it is originated from tropical or subtropical zones rice is a cold sensitive plant. Rice production needs a threshold rainfall of 200 mm/month or 600 mm for a crop season depending on the climate (Matsumoto *et al*., 2014).It is adapted to a wide range of soil regimes in the tropics, ranging from sand to heavy clays. However, most rice varieties can grow on well-structured soils of texture ranged in sandy loam to clay loams, which provide enough soil, water, aeration and penetrability (Jalloh *et al*., 2011).

According to FAO (2009) in Ethiopia four rice production systems are identified and categorized as upland, hydro orphic, irrigated and paddy rice.Upland rice,which is grown on naturally drained soils and where the water table always remains below the roots and is entirely rain fed. Hydro orphic rice (rain fed lowland) which is grown on soils where the roots are periodically saturated by fluctuating water table in addition to the rainfall.Irrigated lowland ecosystem, where by crop water requirement is entirely satisfied from irrigation and rainfall is not a limiting factor and Paddy rice (with or without irrigation) which is grown under water-logged or submerged condition.

2.2 Rice Production and Importance in Ethiopia

In Ethiopia, rice production has started a few decades ago and now the country is proved to have reasonable potential to grow different rice types. Rice is among the most important cereal crop grown in different parts of Ethiopia as a food crop. Currently small-scale farmers grow rice in different parts of the country, but it is also produced by large-scale farms in few lowland areas of the country. Dawit (2015) reported that predominant potential areas are:-West central highlands of Amhara Region (Fogera,Gonder Zuria, Dembia, Takusa and Achefer);North West lowland areas of Amhara and Benshangul Regions (Jawi, Pawi, Metema and Dangur);Gameblla regional state(AboboandEtangWoredas)SouthanSouthWestLowlandsofSNNPR(Beralee,Weyito,Omorate, GuraFerdaandMenit);SomaliRegion(Gode);SouthwesternHighlandsofOromiaRegion(Illuababora , East and West Wellega and Jimma Zones).

With about 17 million hectares of land suitable for rice production Ethiopia has tremendous potential to increase its rice-growing area and is seeking partnerships to make use of this land. Since 2006, Ethiopian rice production trends show increases in both area and productivity.Due to the introduction of upland and irrigated rice varieties in the country; rice farming has increased from time to time.There have been a number of upland/lowland NERICAs and Sativa-type and irrigated rice varieties released in Ethiopia from 1999 up to 2013 some of these are NERICA-1, NERICA-14 NERICA-6, NERICA-15, Hibire, Ediget, Hiddasse, Getachew, Andassa, NERICA-4, SUPERICA-1 ,Tigabe and Kokit Pawe-1(MoARD, 2014).However, the yields of both upland and lowland rain-fed rice are still lower than in other countries,improved technologies and varieties could increase the yields in the coming years (Negussie and Alemu, 2011).

Rice becomes a commodity of strategic significance across many parts of Ethiopia for domestic consumption as well as export market for economic development (Hegde and Hegde,2013).Rice production has brought a significant change in the livelihood of farmers and created job opportunities for a number of citizens in different areas of the country. According to Berhanu and Dirk (2007) in Fogera woreda 72% of the households are producers of rice and about 50% of the farmers sell rice in the area. Similarly, Meron (2016) reported that the cost-benefit analysis of rice production at Fogera district shows that rice production is a profitable business for farmers. She further states that farmer obtained a net profit of 11,890.40 Birr per hectare. Generally, rice production in Ethiopia has big potential to contribute to food security and even to generate foreign currency from its export (Halos-Kim, 2015).As a food crop rice has some inherent characteristics which make it attractive for small-scale farmers as well as for the urban poor and rich.It fits easily into the lifestyles of the people especially to prepare different dishes like injera which is the common food of Ethiopians. In most cases rice is eaten in the form of injera lonely or in combination with other food crops like sorghum and teff moreover, eaten in the form of kita, porridge (gonfo) and bread (dabo). It is also used for local drinks like tella.Furthermore, rice has some inherent characteristics which make it attractive that can available all year round because of its long shelf-life,making it preferable to other crops for food security (Ndemo and Hadush, 2015).

2.3 Response of Rice to Nitrogen

Among the macronutrients in the soil,nitrogen plays an important role in the growth and development of plants.It is an essential constituent of metabolically active compounds like protein, nucleic acids, chlorophyll and enzymes (Pervez *et al*., 2004).Generally, N is involved in cell multiplication, giving rise to the increase in size and length of leaves and stems, especially the stalks of grains and grasses; increases in chlorophyll contents, giving the leaves their dark green colour; plays a part in the manufacture of proteins in the plant and is part of many compounds in the plant, including certain types of basic acids and hormones (Ortiz-Monasterio *et al*.,1997).Plants use large amounts of nitrogen during vegetative growth; it stimulates the production of the vegetative growth parts at the expense of fruiting and food storage parts (Ignatius, 2011).

Chlorophyll is a green pigment found in plants and it is necessary for photosynthesis and enables plant development, nutrient storage in different organs and nutrient cycling through transferring energy from sunlight by photosynthesis. Nitrogen is one of the basic components of chlorophyll inside.In addition it is also effective in the enzymatic carbon metabolism and photosynthetic electron carriers system. Therefore, nitrogen supply to the plant will influence cell size and leaf area, chlorophyll formation and photosynthetic activity. In turn, this influences the amount of protein (Hansen *et al*.,2005).Photosynthesis capacity is affected by nutrient elements, especially nitrogen.Net photosynthesis rate of C_3 and C_4 plants varies depending on the amount of nitrogen. Nitrogen accumulated in the leaves delays aging of the leaf.

In cereals, leaves remain green for long, especially in the greens for a long time in the period of ear emergence increases photosynthetic activity (Ozen and Onay, 2007).Leaves are the organ contributing to the formation of yield in plants most. Approximately 70 - 90% of the final grain yield is derived from photosynthate (products of photosynthesis) produced by the plant during the grain filling.The flag leaf and head usually contribute most,but certainly not all of the photosynthate to the grain (Yildirim *et al*., 2009).Nitrogen absorbed by rice during the vegetative growth stages contributed in growth during reproduction and grain-filling through translocation (Norman *et al*.,2003; Bufogle *et al*.,1997).N being the major component of chlorophyll and hence possessing the important role in photosynthesis plays its role in yield maximization due to more accumulation of assimilates that resulted in heavier grains (Tisdale *et al*., 1990).

There are many reports available that highlight the role of N in enhancing the rice kernel yield due to its involvement in enhancing fertile tillers, kernel weight, number of kernels per panicle and harvest index (Ahmad *et al*.,2005;Manzoor *etal*., 2006; Rajarathinam and Balasabramaniyan, 1999; Lin *et al*.,2009).Nitrogen in combination with proper seeding densities may play its role for optimizing rice yields per unit area (Lin *et al*.,2009). Several reports highlight the positive correlation between higher levels of N application along with higher seedlings density to harvest maximum potential of different rice cultivars including hybrids as well (Ahmad *et al*., 2005; Salahuddin *et al*., 2009; Lin *et al*., 2009).Higher harvest index at higher N levels along with two seedlings per hill might be due to their higher kernel and lower straw yield that indicate efficient assimilate portioning. Nitrogen is very essential for the growth and development of crops. It enhances biomass and seed yield subject to the efficient water supply.Lack of N results stunted growth,pale yellow color,small grain size and poorvegetativeaswell as reproductive performance. Nitrogen is an essential component of amino acid and related protein of the plant structure.

Growth of plants primarily depends on nitrogen availability in soil solution and its utilization by crop plants during growth and development.Dry matter production and its conversion to economic yield is a cumulative effect of various physiological processes occurring during the plant life cycle. Many studies have come to the conclusion that rice in all circumstances responds to the application of nitrogen.Since nitrogen is present in many essential compounds it is not surprising that growth without added nitrogen is slow (Salisbury and Ross,1992).Nitrogen makes up 1 – 4% of the dry matter of plants. It being the essential constituent of protein is involved in all the major process of development and a good supply of nitrogen to the plant stimulates root growth and development as well as uptake of other nutrients (FAO, 2000; Brady and Weil, 2002).One of the most important functions of N in rice is the promotion of rapid growth through increase in height, tiller number, size of leaves and length of roots.

Application of N usually increases plant height, however, excessive concentration of N resulting from further increase in applied N rate reduces plant height (Thakur, 1993; Hari *et al*.,1997; Behera, 1998).Nitrogen deficiency causes stunted plant growth, development of thin and spindle system, low protein, and high sugar content (thickening of cells) and formation of chlorosis as a deficiency symptom on older leaves,which may progress to necrosis under severe condition. Excess nitrogen supply causes higher photosynthetic activity, vigorous growth, weak stem, dark green color, reduced product quality, delay in maturity, increase in susceptibility to insect pests and diseases and building up of nitrate in foliage which is harmful to animals (Mengel and Kirkby, 1996; Tisdale etal,1999;Brady and Weil, 2002).Nitrogen is the most important and the most growth-limiting element in rice (Yoseftabar,2013).

The effect of N on the plant can be explained based on the fact that N supply increases the number and size of meristematic cells which leads to the formation of new shoots (Lawlor, 2002). Furthermore, N application is known to increase the levels of cytokinin which affects cell wall extensibility.It is, therefore, logical to speculate that N was involved directly or indirectly in the enlargement and division of new cells and production of tissues which in turn were responsible for the increase in growth characteristics particularly tiller numbers of the rice (Haque and Haque,2016).The growth of rice is described by tiller number, dry matter production, leaf area development, crop growth rate and net assimilation rate under variable nitrogen rates. The number of tillers per hill of rice increased over time by a gradual elevation of nitrogen fertilizer up to 45 days of transplanting afterward showed a falling trend. The reduction of tiller number per plant at later growth stage might be due to tiller mortality under intra-plant competition for growth resources (Haque and Haque, 2016).According to Kumar *et al*.(2014) and Ehsanullah *et al*.(2012) plant height might be increased due to enhanced vegetative growth with more N supply to the plant.

2.3.5 Flowering and maturity

Application of nitrogen fertilizer has been reported to promote early flowering in rice crop (Tanaka,1995;Takahashi *et al*.,1995).Moreover, excessive nitrogen fertilizer results in the delayed maturity of rice crop by affecting the supply of photosynthesis during critical period of the reproductive phase (Ishizuke, 1980).Moreover,when nitrogen fertilizer is applied in excessive amount to the rice crop, the sugar concentration in the leaves is reduced during the early ripening stage and translocation of assimilated products to spikelet's is inhibited (Tanaka, 1995).Nitrogen applied at flowering increased flag leaf N content significantly for rice.Rakesh *et al*.,(2012) and Dechassa and Handiso,(2014) who was noted that days to 50% heading of crop was hastened under lower N rates compared to the higher rates

This increase is also observed for the rest of the leaves besides the flag leaf. RuBisCo (ribulose-1, 5-bisphosphate carboxylase/oxygenase) content of the flag leaves is higher for the plants that received N at flowering. This directly enhanced photosynthetic rate and leaf N concentration of the flag leaves (Peng *et al*., 1998).In rice, 60–90% of the total carbon accumulated in panicles at the time of harvest is derived from photosynthesis after heading; and the flag leaves are the organs that contribute most to grain filling (Yoshida,1981). On the other hand, the maturity of the crop is delayed when N is applied in excess (Wild and Jones, 1988) that affects the supply of photosynthesis during a reproductive phase (Marschner, 1995).

2.3.1 Role of Nitrogen on Yield and Yield Attributes of Rice

Yield attributes in rice crop consists of the number of panicle per unit area, number of spikelets per panicle, percentage of filled (ripened) spikelet's and thousand grain weights (Jocquot and Courts, 1987; Singh and Singh, 1993).The magnitude of the response of rice crop to nitrogen varies with type and amount of nutrient applied. Application of nitrogen fertilizer increases the number of grains per panicle as well number of productive tillers (De Data and Patrick, 1986; Singh and Singh, 1993).Among all the yield attributes of rice panicle number m^{-2} is highly correlated with grain yield and it is the most important factor that causes variation in grain yield (Miller *et al.,* 1991; Gravois and Helms, 1992; Thakur, 1993).

Likewise, number of spikelets per panicle is another important yield attribute of rice. Increasing N application results in a greater number of rice spikelets per panicle (Sagar and Reddy, 1992; Patra *et al.*,1992; Thakur, 1993; Rathi and Sharma, 1996).Since the grain size in rice is fairly constant (Yoshida, 1981), sink capacity is primarily limited by spikelet number, which in turn, has a close association with N nutrition of the crop (Shiga and Sekiya, 1976).Mannan *et al.*

(2010) reported that maximum plant growth at the highest level of 100 kg ha^{-1} of N caused lodging of plant which increased spikelet sterility and lower number of grains per panicle and ultimately decreased grain yield.

Application of excessive nitrogen fertilizer has detrimental effect on spikelet formation, which in turn reduces grain yield. Because the rate of carbohydrate flow determines plant organ proliferation an increase in competition for carbohydrate assimilates among tillers decreases the production of spikelets per panicle (Pal, 2004).On the other hand, as the number of spikelets increase with increasing nitrogen supply, serious competition for carbohydrate will take place among spikelets. Weak spikelets in the lower parts of panicle normally fail to be fertilized or get aborted immediately after fertilization (Tanaka,1995; Takahashi *et al.*,1995). Synchronization of nutrient supplementation to the crop plants with the demand is the important basis of getting higher yields.It is also possible that vigorous vegetative growth can cause a heavy drain on soluble carbohydrate, resulting in reduction of its availability for spikelet formation. Some research reports indicate that where the yield response to nitrogen fertilizer is negative, and in those cases, yield reduction was primarily caused by a reduction in the proportion of filled grains (IRRI, 1964; Tanaka, 1995).

Number of filled spikelets per panicle was reported to increase to a certain level of nitrogen supply followed by decline with further increase of nitrogen fertilizer levels (IRRI, 1994).Increasing nitrogen levels beyond optimum level quite often increases number of unfilled spikelets per panicle .Grain yield is partly attributed to increase in grain weight. Application of nitrogen to optimum level increases thousand grain weights in rice crop. Because the proportion of filled spikelets at flowering is influenced by assimilate supply, increase in number of spikelets per panicle and vigorous vegetative growth owing to high nitrogen fertilizer application induces competition for carbohydrate available for grain filling and spikelet formation. This reduces the grain weight because of insufficient supply of carbohydrate to the individual grains (Tanaka, 1995; Takahashi *et al*., 1995).

2.3.2 Role of nitrogen on grain yield of rice

It is quite natural that increasing levels of applied N increased grain yield of rice (Panda *et al.,* 1995; Rathi and Sharma, 1996; Behera, 1998).Increasing N levels increased grain yield by increasing the magnitude of yield attributes. The increase in yield attributing characters, result of better nutrition or N uptake of rice crop (Rathore *et al*., 1991; Thakur, 1993) leading to greater dry matter production and its translocation to the sink (Dalal and Dixit, 1987). Yoseftabar (2013) studied on nitrogen management on panicle structure and yield in rice showed that panicle number, panicle length, panicle dry matter, number of primary branches, total number of grains and grain yield were highest by the application of 300 kg/ha of nitrogen than 100 or 200 kg/ha of nitrogen.The number of effective tillers rather than total number of tillers contributes more to enhance productivity of rice plant. A number of reports had showed it's ability to increase yield when applied to the optimum level. At Fogera plains, northwestern Ethiopia, the highest rice mean yield was obtained due to the application of 60 kg N ha^{-1} represented an increase of 38.5% over the control (Mulugeta, 2006). Malik *et al.* (1994) reported that the optimum N requirement of rice was 84 kgN ha^{-1}.Shiferaw *et al.* (2012) also reported further increase of N from 92 kg ha^{-1} showed decline in yield because longer and droopy leaves causing lodging and other mechanical effects.

Mannan *et al.* (2010) reported that maximum plant growth at the highest level of 100 kg ha^{-1} of N caused lodging of plant which increased spikelet sterility and lower number of grains per panicle and ultimately decreased grain yield. Nitrogen is also very important to yield because of its key role in cell division. If cell division is stopped, the leaf area decreases and crop plant thereby loses its potential to produce an adequate yield (Gholizadeh *et al*.,2009).According to (Azarpour *et al.*,2014) maximum grain yield (4328 kgha^{-1}) was obtained from 90 kg ha^{-1} nitrogen fertilizer level and other fertilizer treatments were put in lower levels.Similarly, Bekele and Getahun, (2016) reported that applied N increases rice grain yield from 3867 kg ha^{-1} to 5692 kg ha^{-1} and significantly improved the number of panicles per square meter by 11.5% to 16.1% over zero-N. He also reported that a number of panicles per m^{2} and number of filled spikelet's per panicle as well as panicle length were the most important yield forming attributes causing significant variation in grain yield of rice. Moreover, Tayefe *et al*. (2014) who illustrated that total biomass (8386 kg/ha), grain yield (3662 kg/ha), plant height (127 cm), tillers per m^{2} (250), panicles per m^{2} (235) and total grain per panicle (103.8) reached the highest value at increasing nitrogen rate from 0-90 kg N ha^{-1}.

Finally, Haque and Haque,(2016) observed that application of nitrogen from 0 to 60 kg N ha^{-1} increased panicle per hill, grains per panicle, filled grains per panicle and seed size which ultimately increased the yield of the rice. Increase in level of nitrogen fertilizer increased the number of grains in rice. Higher number of grains per panicle at higher nitrogen rate might be due to higher nitrogen absorption which favored formation of higher number of branches per panicle (Rahman *et al.,* 2007).Hassan *et al.*,(2007) showed that vigorous biomass accumulation could lead to dilution of plant nitrogen content up to the panicle initiation stage, which could lead to inefficient use of nitrogen for spikelet formation.

2.3.3 Role of nitrogen on dry matter and straw yield of rice

Increasing N fertilizer rate was reported to increase dry matter accumulation in rice (Sudhakar *et al*., 1987; Hari *et al*., 1997) by enhancing N uptake (Dalal and Dixit, 1987). Increasing dry matter is attributed to increase in length of leaves, elongation of stem and panicles,or in general to increase in vegetative growth of the plant (Kumbhar and Sonar,1980).Results of several studies have shown that application of N tends to increase the biomass of different crops. Zia *et al.* (1992) reported 40% increase in biomass of rice with the application of 80 to 150kg N ha-1.Sewenet (2005) observed a significant increase in plant height with the application of 46 and 69 kg N ha^{-1}.According to Mulugeta (2006) reported that increasing the levels of applied N increased dry matter accumulation and straw yield of rice significantly up to 90 and 120 kg Nha^{-1}.

Similarly,Haque, and Haque (2016) noted that the nitrogen fertilization, the highest dry matter (1138.40 $g{\cdot}m^{-2}$) was obtained when rice plants were fertilized with 100 kg N ha^{-1} and the lowest (19.74 $g{\cdot}m^{-2}$) dry matter was obtained in control treatment. This is attributed to enhanced plant N uptake(Dalal and Dixit,1987).Thereby promoting the vigorous vegetative growth of the rice crop. A similar result obtained by Bekele and Getahun (2016).Results of above researcher have shown that application of N tends to increase the biomass of rice crops.Yosef Tabar (2011) also reported similar results showing increased response of rice biomass to N 50, 100 and 150 kg ha^{-1} fertilizer.Increasing fertilizer nitrogen rate increased dry matter accumulation in rice crop by promoting nitrogen uptake. Increased dry matter is attributed to increase in length of leaves, elongation of stem and panicles causing overall increase in vegetative growth of plant (IRRI, 1994). Increasing application of fertilizer 46 kg N and 10 kg P ha^{-1} increases N and P uptake due to effective phosphorus absorption and through enhancing uptake of other nutrients and thereby resulting in increased dry matter production (Zewdie, 2004).

2.3.4 Role of nitrogen on harvest index

Harvest index represents the ratio of grain yield to the total dry matter production (Marschener, 1995).Tanaka (1995) indicated that harvest index in rice is closely related to the percentage of productive tillers and generally decreased with increase of N application.An increase in N application favors huge vegetative growth and thereby results in lower percent of productive tillers, panicle number and finally lower harvest index (Tanaka, 1995). Such a decreasing trend of harvest index with increased rate of N application has been confirmed by several studies (Kumar and Rao, 1992; Patra *et al*.,1992;Hari *et al*.,1997).However, with moderate doses of N application, increment of harvest index can be achieved (Kanungo and Rout, 1994). Behera (1998) and Thakur (1993) also reported an increasing trend of harvest index to a certain level of N and a decreasing one with further increase in its rate of application.

2.4. Nitrogen Use Efficiency of Rice

Nitrogen fertilizers are a major input cost in rice production and its excess application leads to major environmental pollution.Therefore; should be increased NUE to mitigate the economic and environmental costs of rice production (Selvaraj *et al*., 2016). NUE was defined as crops that can more efficiently uptake, utilize and remobilize the N available to them (McAllister *et al*., 2012;Han*et al*., 2015).The estimation of nitrogen use efficiency (NUE) in crop plants is crucially needed to assess the fate of applied nitrogen and their role in improving maximum economic yield through efficient absorbed or utilization by the plant.The diminishing trend of NUE at higher N rates pointed out that rice plants are unable to absorb or utilize N at higher rates or the rate of N uptake by the plant cannot keep pace with the loss of N (Fageria,and Baligar,2005). Rice needs nitrogen during its whole growth cycle however,relatively initiation of panicle, flowering and physiological maturity were the most critical growth stages for nitrogen tissue analysis to determine optimum concentration or nitrogen uptake for maximum shoot and grain yield (Fageria, 2003;Li *et al.*,2003).The uptake and concentration of N in the important tissues of rice like leaves, grain and straw usually increase by increased level of fertilizer N (Kumar and Rao,1992; Panda *et al*.,1995; Singh *et al*.,1995).This increase in N uptake with increasing N levels in soil is mainly due to increased N availability around the root zones and higher dry matter accumulation through increased root growth and effective absorption (Kumar and Rao,1992).According to Borrell *et al.*(1998), with low level of N in soil, rice tissue concentration and uptake become low and grain yield is analogous to N uptake.With higher rate of fertilizer N, Borrell *et al.*(1998) recorded 3.50 to 3.77% of N concentration in rice leaves at the panicle initiation stage.Yoshida (1981) and Dobermann and Fairhurst (2000) reported that the critical level for deficiency of N concentration in rice crop at flowering was less than 2% in flag leaf and less than 2.5% in leaf at the tillering to panicle initiation stage.

Nitrogen usually loss by means of ammonia volatilization, denitrification, surface runoff and leaching in the soil floodwater system (De Datta,1989) causing enormous problems for instance environmental pollution, increased production cost, grain yield reduction and could even lead to global warming(Li*et al.*,2012).Nonetheless,the magnitude and nature of N losses vary depending on the timing, rate, and method of N application, the source of N fertilizer, soil chemical and physical properties, climatic conditions and crop status (Zhu,1997).Eagle *et al.* (2001)Timsina *et al.* (2001) have also reported decreases in N uptake efficiency at higher N rates.Application time and the amount of nitrogen fertilizer are among the key management methods which can be used to increase the efficiency of nitrogen application.

In order to increase the efficiency and thus accurately and appropriately apply nitrogen fertilizer, needs of plants during their growth period must be properly understood. Nitrogen is required during all the growth period of rice plant (Tari andAmiri, 2015).The four right nutrient management principles (right source, right rate, right time and right placement) summarize the best management principles to achieve high NUE(IPNI,2016).Therefore, managing N application to rice is an essential activity to reduce N losses and to improve N use efficiency which in turn improves rice grain yields (Merkebu and Techale, 2015).Agronomic N use efficiency (ANUE) was defined as the ratio of grain yield with N application minus grain yield without N application to N application and was used to describe the capability of yield increase per kilogram pure N. Excessive use of N fertilizers resulted in a decrease in physiological N-use efficiency and causes serious environmental pollution (Jiang *et al*., 2005). Similarly, Kumar *et al*. (2014) reported that the uptake of N by different rice varieties increases with increasing the rates of N application, but it reduces the N use efficiency.It was observed that with increasing N application, ANUE and

PNUE (Physiological N use efficiency) of all genotypes were decreased significantly.It indicated that the capability of increase in yield per kilogram pure N declined remarkably with increasing N application.

A similar result has been reported by Li *et al*. (2012), who showed that lower PNUE under high N supply will finally result in a lower NUE.Similar results were also reported by (Ye *et al*.,2007 and Ju *et al*., 2015). Different nitrogen application methods can be effective in the nitrogen status of grain and above ground organ so that appropriate splitting during different Phenological stages of rice could lead to more desirable absorption and allocation of nitrogen in vegetative and reproductive organs of this plant. Fageria (2009) reported that the greater amount of N uptake or accumulation in grain of crop plants is important, because crop yield is significantly and linearly associated with N accumulated in grain.

Generally, N uptake in grain has positive significant associations with grain yield (Fageria and Baligar 2001, 2005).Hence, improving N uptake in grain may lead to improved grain yield. However, different splitting methods had a significant effect on above ground organs nitrogen contents so that nitrogen application at three physiological stages of rice could increase nitrogen content in above ground organs Consuming a higher amount of nitrogen fertilizer caused increased nitrogen content of grain and above ground organ (Tari and Amiri, 2015).Similarly, Fageria *et al*. (2009) demonstrated that increasing application of nitrogen fertilizer from 50 to 200 kg ha^{-1} decreases the physiological efficiency of nitrogen.Craswell and Godwin (1984) opined that high agronomic efficiency is obtained if the yield increment per unit N applied is high because of reduced losses and increased uptake of N.

2.3.6 Response of rice to seed rate

Plant density is defined as the number of plants within a unit area of land.The number of plants per unit area increased, competition for growth resources such as nutrients, water and light also increased.Willey (1982) stated that an essential component of plant density is spatial arrangement, which is the pattern of distribution of plants on the ground. Plants showed extreme plasticity, responding remarkably in size and form to environmental conditions one of the most potent of these external forces is the presence of competing neighbors, which may reduce a plant to a diminutive size (Ahmed, 2013), Increasing seeding rates in direct seeded rice can suppress weed growth and reduce grain yield losses from weed competition. Without optimum plant population, a cultivar cannot give maximum genetic potential.

The yield gap of 50% - 60% between potential and actual yield at farmer's field is accredited to a number of agronomic constraints of which low plant density per unit area, weed infestation and inappropriate sowing methods are the most important ones and have a direct effect on final yield of rice (Akbar, N. and Ehsanullah, 2004). It is possible to increase rice yield at farm level by about 50% - 60% by obtaining an optimum plant population (Miller *et al.*,1991).Low seeding rates resulted in lower dry matter and seed yield than the higher seeding rates (Uzun *et al.*, 2004). The optimum plant population with maximum productive tillers through direct seeding could reduce crop establishment cost.High seeding rate helps to suppress weeds; however, yield does not always increase with high seeding rate and there are some risks associated with this such as crop lodging, diseases, and insect infestation. On the other hand, low seeding rates reduce seed cost.

However, there are also some risks associated with the use of low seeding rate such as losses due to weed competition and poor rice seedling establishment (Ahmed, 2013). Mutual shading of leaves is considered undesirable as it reduced yield directly by reducing light available for photosynthesis and indirectly by allowing light energy to pass directly to the soil, where it may be dissipated as latent heat removing water from the root zone (Wilson and Teare, 1972).There is a logarithmic relationship between population and production of total dry weight per unit area. However, the grain weight per unit area increases with a decrease in spacing up to a certain extent, after which there is no change or a decrease depending on the characters of variety (Kanda and Kakizaki, 1957).

High seed rates can result in large yield losses due to excessive vegetative growth before anthesis followed by a reduced rate of dry matter accumulation after anthesis (Wells and Faw, 1978) and lower foliage N concentration at heading (Dingkuhn *et al*., 1990).These factors result in higher spikelet sterility and fewer grains per panicle (Huan *et al*.,1999; Tuong *et al*., 2000; Baloch *et al*., 2007;Kabir *et al*.,2008;).Moreover,dense plant populations at high seed rates can create favorable conditions for diseases, *e.g.* sheath blight (Mithrasena and Adikari, 1986) and insects and make plants more prone to lodging (Dofing and Knight, 1994; Islam *et al*., 2008). A high seed rate also increases establishment costs.Optimum seed rate also provide better space for leaf growth for better light interception and higher dry matter accumulation which might have resulted in higher grain yield.This was also supported by (Ling *et al.* 2011). Optimum seed rate is most important for maximum yield of crop. If more seed rate is used, plant population will be more and there will be competition among plants for water, nutrients and sunlight resulting in low quality and low yield. If less seed rate is used yield will be less due to lesser number of plants per unit area (Hamid *et al.,* 2002).

Khan *et al.,* (2011) showed that maximum grain yield was obtained with the increase in seed rate while minimum grain yield was produced by low seed rate.Seed rate of 100-120 kg ha^{-1} for broadcasting and 70-90 kg for dibbling or drilling is used .In densely populated rice field the inter specific competition between the plants is high in which sometimes results in gradual shading and lodging and thus favors increased production of straw instead of grain (Faruk *et al.*, 2009).On the other hand, Zeng and Shannon (2000) reported that seeding rates of 100 and 150 kg ha^{-1} were considered to be within the range of normal seeding densities in direct-seeded cultural systems of rice 80 seed kg ha^{-1} for sowing by drilling was recommended by WARDA for upland rice production in drill seeding (WARDA,2008).Sharif *et al.,*(2013) suggest that increasing seeding rates 20 to 100 kg ha^{-1} in direct seeded rice can suppress weed growth and reduce grain yield losses from weed competition.

2.3.7 Interaction between Nitrogen and Seed Rates

Nitrogen and plant density are important factors in determining rice grain yield. High yield of rice is usually obtained by increasing nitrogen application and dense planting.Grain yield of rice increases with the increase in number of hills per unit area as long as there is space in the cultivated field. When the planting density exceeds an optimum level, competition among plants for light aboveground and for nutrients belowground becomes severe.Consequently, plant growth slows down and the grain yield decreases. If mutual shading/overlapping is the limiting factor for nitrogen response, nitrogen response can be improved by giving individual plants more light by increasing the space between them (Sewenet, 2005).Rice yield response to plant density has often been reported to be significantly influenced by the rate of N fertilizer application (Wells and Faw 1978; Nguu and De Datta, 1979).The optimum amount of nitrogen and planting density differ with varieties or genotypes. Many workers reported that the nitrogen level and the degree of spacing determine the growth of cereal crops and modify their characters, that is plant height, heading time, tiller number, panicle number, panicle length, panicle weight and yield. Generally, varietal differences in the response to nitrogen and spacing or both have been recognized in rice (De Datta and Patrick, 1986).

Adaptability to heavy fertilization or dense planting or both is related to the physiological characters controlling the abilities for absorption and assimilation of nitrogen, photosynthesis, translocation and storage of its products, growth of leaves, activity of roots and resistance to lodging and disease (IRRI, 1965).Sewenet (2005) showed that application of 23 kg N ha^{-1} and 120 kg seed ha^{-1} had increased grain yield. The effect of a high crop-seeding rate appears to be more prominent at low N levels because weeds grow slowly at low N levels two seedlings hill-1 at 100kgNha-1proved to be the best combination for maximizing the rice yield (Ehsanullah1, 2011).Nitrogen in combination with proper seeding densities play role for optimizing rice yields per unit area (Lin *et al.*,2009).Rice seedling density per hill and optimal nitrogen fertilization exercises a strong influence on rice growth and grain yield due to competitive effects both on the vegetative and reproductive development.

3. MATERIALS AND METHODS

3.1 Description of Experimental Site

The experiment was conducted at Gojeb in Gimbo district of Kaffa Zone, Southern Nations Nationalities and People's Region (SNNPR).It was executed on a farmer's field during the main cropping season of 2017.It is located at $07^{0}26.71$N Latitude and $036^{0}20.54$ E Longitude at altitude of 1223 m a.s.l. This site was 449 km far from Addis Ababa to southwestern Ethiopia. The climate of the area during growing seson is characterized by a long rainy season and the maximum and minimum temperature described in Apendex (Table 4).Agriculture is the main occupation and livelihood source for the area.The area's crop production is characterized by subsistence oxen plow farming and the major cultivated crops are sorghum,enset, maize,and coffee (GWAO,2016). These crops are mainly used for home consumption while coffee is grown for cash.Large and Small ruminants cow, donkey, horse, poultry and honey bee are the most important livestock.The area is classified in to two agro-ecological zones consisting 78% lowland (*kola*),22% mid altitude (*woinadega*).The soil type of the experimental site is clay loam texture. This site is known to be among the ideal environments for rice trial.

3.2 Experimental Materials

Upland rice variety named NARICA 4 released by Pawe research center (PARC/EIAR) in 2006 was used. The variety is a high yielder, white-seeded capable to adapt a wide range of altitudes (MoA, 2014).As it also tolerant to drought and blast diseases with high potential yield of 5tha^{-1}(WARDA, 2006).Also widely grown by the farmers in the study area.

3.3 Experimental Procedures

The selected experimental land was prepared according to the local practice. It was plowed four times using oxen and the last plow was used for seed bed preparation. After leveling, rows were prepared according to the specified spacing at 4cm depth. Seeds were drilled at specified rate and Nitrogen fertilizer (Urea) level was applied as side banding adjacent to seed or seedling rows. Phosphorus fertilizer (TSP-Triple Super Phosphate) was applied at sowing to all plots equally at rate of 46kg ha^{-1}.Weeding was done manually by hand similar to the farmer's practice.The experiment was established on the field at July 15 , 2017 and harvested on November.

Table 1: Treatment combinations used in the experiment

Seed rate (kg/ha)	N rate (kg/ha)	Treatment combinations (Seed rate, N rate)
50	0	50 kg/ha , 0 kg/ ha
	32	50kg/ha , 32 kg/ha
	64	50 kg/ha , 64kg /ha
	96	50kg/ha , 96kg /ha
	128	50 kg/ha,128 kg/ha
60	0	60kg/ha , 0 kg/ha
	32	60 kg/ha ,32kg/ha
	64	60 kg/ha ,64kg/ha
	96	60 kg/ha ,96 kg/ha
	128	60 kg/ha,128kg/ha
70	0	70 kg/ha ,0 kg/ha
	32	70 kg/ha ,32 kg/ha
	64	70kg/ha , 64kg/ha
	96	70kg/ha , 96kg /ha
	128	70kg/ha,128kg/ha

3.4 Treatments and Experimental Design

The experiment was conducted with five nitrogen levels (0, 32, 64, 96 and 128 N kg/ha) and Three seed rate level (50, 60 and 70 kg/ha).The base of selecting this treatment is due to national blanket recommendation of nitrogen fertilizer 64kg/ha and seed rate 60kg/ha for rice production .The experiment was laid down on factorial arrangement of randomized complete block design (RCBD) with three replication. All other management practice was applied to each treatment as recommended. The total plot size and net plot size were 2m *3m and 1.75m*3m respectively. Spacing: 25cm between rows, 50cm between plot, 1m between replication and drilling method of planting was used .Each plot has 12 row and data was recorded in the center 8 row.Nitrogen split was applied three times with 1/3 of the N applied at planting, 1/3 of the N applied at active tillering and the remaining 1/3 of the N applied at panicle initiation based on national recommendation for rice.

3.5 Data Collected

Observation and data recorded for all traits studied was made based on the Standard Evaluation System for Rice (IRRI, 2002) and Bioversity International, and WARDA (2007) procedures.

3.5.1 Phenological and plant growth parameters

Plant height: It was taken before physiological maturity and measured from the ground level to the tip of a panicle often randomly selected ten plants and expressed in cm.

Days to 50% heading: It was visually determined by counting the number of days from sowing to the time when 50% of the panicles in the plot have partially exerted their panicles from the boot.

Days to 50% flowering: It was visually determined by counting the number of days from sowing to the time when 50% of the panicles in the plot have partially flower.

Days to 90% physiological maturity: It was determined by counting the number of days from sowing to the time when the plants show senescence of the leaves and free-threshing of grain from the panicle when pressed between the forefinger and thumb.

Panicle length: it was taken before physiological maturity, measured from neck node to the tip of a panicle ten randomly selected plants, and expressed in cm.

3.5.2 Yield and yield components

A number of effective tillers per m^2: It was taken from the middle rows on 0.5m x 0.5m quadrant before physiological maturity. The number of all effective tillers were counted and recorded.

A number of total tillers per m^2: It was taken from the middle rows on 0.5m x 0.5m quadrant at booting stage. The number of all emerged tillers were counted and recorded.

A number of filld grains per panicle: the number of grain was determined by counting only filled grain from ten randomly selected sample plants in each plot and average.

A number of unfilled grains per panicle: the number of grain was determined by counting only unfilled grain from ten randomly selected sample plants in each plot and average.

Grain yield (kg ha^{-1}): grain yield was measured by harvesting the crop from the net middle plot area of 2 x 3m excluding borders on four sides of the plot.The harvested rice was threshed and cleaned accordingly prior to weighing. Moisture percentage of harvested rice was measured three times.Plot paddy rice yield was determined by adjusting the weight at the standard 14% moisture content using the formula that follows.Paddy rice weights of each plot were recorded and converted into kg/ha as described by Gomez (1972).

$$Adjusted\ grain\ weight = \frac{100 - AMCActual\ moisture\ during\ weighing}{86} xpaddy\ weight$$

Thousand Seed Weight (gram): Thousand grains weight was determined from bulked grain samples in each plot and recorded on 14% seed moisture content basis and by counting the randomly sampled rice grains and weighing them using a sensitive balance.

Total above-ground dry biomass (kg ha^{-1}):dry biomass was determined by taking the total weight of the harvest including the grain from each net plot area at physiological maturity after oven dry at 70^{o}C for 72 hours drying the biomass to constant weight.

Straw yield (kg ha^{-1}): After drying straw in the oven which is taken from 0.5m x0.5m weighing by sensitive balance and converted into kgha^{-1}.

Harvest index: After drying in an oven the grain and straw.Harvest index was calculated by dividing grain yield per total dry biomass multiplying by 100. (Fageria, 2001).

$$Harvest\ index = \frac{Grain\ yield\ (g)}{Total\ biomass(g)}\ x\ 100$$

3.6 Plant Tissue Sampling and Analysis

Plant samples were taken from an area of 0.5 x 0.5m quadrant on each plot at harvest. The collected samples were partitioned into vegetative and grain for the determinations of N concentrations,uptake and use efficiencies and analyzed in JARC (Jimma Agricultural Research Center) laboratory.Then the samples were oven dried at 70 °C for 24 hours or to constant weight and ground and sieved through 0.1mm size sieve prior to analysis.Grain and strawnitrogen content was determined by the methods of micro-Kjeldal digestion,distillation,and titration (Fageria*etal,*2009).Also analyzed with EIAR/RL/JARC/SOP5.4-14(Kjeldahl)using NSRC/EAR O / PSPAmanual(2000).The wet digestion method,which involves the decomposition of the plant tissues and grain using various combinations of HNO_3, H_2SO_4 and $HClO_4$. From the digest, N was measured using the Kjeldahl procedure.Total N uptakes in straw and grains were calculated by multiplying the N contents by the respective straw and grain yields /100.Total N uptakes by the whole plant were determined by summing up the respective grain and straw N uptakes on hectare basis (Aon *et al.,* 2015).

$$Nitrogen\,uptake\;of\;grain = \frac{N\,concentration\;of\;grain\;x\;grain\,yield(kgha^{-1})}{100}$$

$$Nitrogen\,uptake\;of\;straw = \frac{N\,concentration\;of\;straw\;x\;straw\,yield\;(kgha^{-1})}{100}$$

$$Total\;Nitrogen\,uptake(TNU) = N\;uptake\;of\;grain + N\;uptake\;of\;straw$$

3.6.1 Nitrogen use efficiency

Agronomic efficiency, physiological efficiency and recovery efficiency were computed according to the formulae described by Fageria and Baligar (2003) and Fageria and Baligar (2005).

Agronomic efficiency (AE): the agronomic efficiency is defined as the economic production obtained per unit of nutrient applied. It can be calculated by:

$$AE(kgkg^{-1}) = \frac{Gf - Gu}{Na}$$

Where Gf is the grain yield of the fertilized plot (kg), Gu is the grain yield of the unfertilized plot (kg), and Na is the quantity of N applied (kg).

Physiological efficiency (PE): Physiological efficiency is defined as the biological yield obtained per unit of nutrient uptake. It can be calculated by:

$$PE(kgkg^{-1}) = \frac{BYf - BYu}{Nf - Nu}$$

Where, BYf is the biological yield (grain plus straw) of the fertilized plot (kg ha^{-1}), Byu is the biological yield of the unfertilized plot (kg ha^{-1}), Nf is the nutrient uptake (grain plus straw) of the fertilized plot (kg ha^{-1}), and Nu is the N uptake (grain plus straw) of the unfertilized plot (kg ha^{-1}).

Apparent Recovery Efficiency (ARE): Apparent recovery efficiency is defined as the quantity of nutrient uptake per unit of nutrient applied. It can be calculated by:

$$ARE(\%) = \frac{(Nf - Nu)}{Na}x100$$

Where Nf is the N uptake (grain plus straw) of the fertilized plot (kg ha^{-1}), Nu is the N uptake (grain plus straw) of the unfertilized plot (kg ha^{-1}), and Na is the quantity of N applied (kg ha^{-1}).

3.7 Soil Sampling and Analysis

Soil samples were collected at a depth of 0-30 cm from the experimental field in zigzag sampling way and composited into one representative sample before planting.The collected sample were analyzed in JARC laboratory for selected chemical and physical soil properties at Jimma Agricultural Research Laboratory.The soil samples were air-dried and passed through a 2mm mesh sieve for physicochemical analysis.In the laboratory, the pre-plant composite soil samples were used to determine organic carbon, total N, soil pH (H_2O), available phosphorus, cation exchange capacity (CEC) and texture.Organic carbon content was determined by the volumetric method (Walkley andBlack,1934) as described in Food and Agriculture Organization of the UnitedNations(FAO)guidetolaboratoryestablishmentfor plant nutrient analysis (FAO,2008).Total nitrogen was analyzed by Micro-Kjeldhal digestion method with sulphuric acid (Jackson, 1962).

The pH of the soil was determined according to FAO (2008) using 1:2.5 (weight/volume) soil sample to water ratio using a glass electrode attached to a digital pH meter.The total number of exchangeable cation soil can hold,cation exchange capacity (CEC) was measured after saturating thesoilwith1Nammoniumacetate(NH4OAc)and displacing it with1NNaOAc(Chapman,1965). BrayII method extraction method (Bray and Kurtz,1945)was followed for available P.Particle size distribution (soil texture) was done by hydrometer method (differential setting within a water column) using particles less than 2 mm. Accordingly, the procedure measures percentage of sand (0.05-2.0mm),silt (0.002-0.05mm)andclay(< 0.002mm)fractions in soils (FAO,2008).The pre-sowing soil analysis showed that the experimental soil had a pH $_{(H2O)}$ of 5.50 (moderately acidic).

Somado *et al*.(2008) reported optimum soil pH for rice growth in dry conditions is 5.5-6.5.Thus, the pH of the experimental soil was within this range and suitable for rice cultivation.The texture of the soil has compositions of 42% clay,26% silt, and 32% sand, which is in the textural class of clay loam in which it is also suitable for upland rice as well as for other agricultural crops (Tekalign,1991).Thus soilpH which was moderatelyacidic 5.50 is in the range for rice production.Tekaligne *et al.*,(1991) classified soil total N availability of <0.05% as very low, 0.05-0.12% as poor,0.12-0.25% as moderate and >0.25% as high.According to this classification,the total nitrogen of the study site (0.263%) was high.The soil cation exchange capacity describes the potential fertility of soils and affected by the soil texture, organic matter content and the dominant types of clay minerals present.

According to Landon (1991) top soils having CEC greater than 40 Cmol (+) kg^{-1} are rated as very high and 25-40 Cmol (+) kg^{-1} as high, 15-25 as medium 5-15 low and < 5 Cmol (+) kg^{-1} of soil as very low in CEC. According to this classification, the soils of the site had high CEC of 37.04 Cmol (+) kg^{-1}. The analysis revealed that the soils available P was 8.063 ppm which is rated as low this is due to fixation as described the soil is moderately acidic .According to Tekalign *et al*. (1991) where they described soils with available P < 10, 11-31, 32-56, > 56ppm as low, medium, high and very high, respectively.The Netherlands commissioned study by Ministry of Agriculture and Fisheries (1995) classified soil organic carbon (%) >3.50, 2.51-3.5, 1.26-2.50, 0.60-1.25 and< 0.60 as very high, high, medium, low and very low, respectively.Thus, the organic carbon content of the soil (3.397%) is in high range. Thus, considering the soil parameters at the experimental site is suitable for rice production except the low available P.

Table 2: Selected physicochemical properties of the experimental soil before planting

Parameter	Value	Rating	Reference
Sand (%)		32%	
Clay (%)		42%	
Silt (%)		26%	
Textural class		clay loam	FAO (2013)
Soil pH (1:2 H2O)	5.50	Moderately acidic	Landon (1991)
OC (%)	3.397	High	Hazelton and Murphy (2007)
TN (%)	0.263	High	Tekalign *etal* (1991)
Av.p.ppm	8.03	low	Hazelton and Murphy (2007)
CEC (Cmol)	37.04	High	Roy *etal*, (2006)

Where, Cmol= Cent mole; pH=hydrogen power; %OC=percent of organic carbon;TN=Percent of Total nitrogen; Av.p.ppm=available P in parts per million; CEC=Cation exchange capacity

3.8 Statistical Analysis

Data was analyzed statistically by using analysis of variance (ANOVA) technique with the help of SAS computer software program (SAS,2014) on version 9.3.When significant difference existed between treatments, comparisons of means were done by using the Least Significant Difference (LSD) test at 5% probability levels. In addition correlation analysis of variables were done.

Model

$$Y_{ijk} = \mu + r_i + a_j + b_k + ab_{jk} + e_{ijk}$$

Where $Yijk$ = the value of the response variable

μ = common mean effect

aj = Effect of seed rate application

ri = effect of replication

b_k = effect of Nitrogen rate

ab_{jk} = interaction effect of seed rat and nitrogen application

e_{ijk} = experimental error (residual) effect

3.9 Partial Budget Analysis

To evaluate the economic viability of the technologies partial budget analysis is performed. In this study, the partial budget analysis was conducted for economic analysis of the different rate of N fertilizer and seed carried out using combined grain yield data. The yield response of seed rate to the applied fertilizer rate was estimated, where the price of fertilizer and seed costs that varied during cultivation determined the economic feasibility of fertilizer and seed rate application. Therefore, the main purpose of partial budget analysis in the study was to evaluate the difference in cost and benefits among different nitrogen and seed rate application. For the time being, the yields of all treatment were adjusted downward to 10% to reflect the difference between the experimental yield and yield of farmers due to differences in management factors. The price of nitrogen and seed per quintal (ETB 1050) and (ETB 1500) respectively, application cost of nitrogen fertilizer and seed was included in the total variable cost using the local wage rate for the N applied (ETB 50) person per day.

The farm gate price of grain was (ETB 10) per kg. A gross farm gate benefit was obtained by multiplying adjusted yield (kg ha^{-1}) with farm gate price (ETB kg^{-1});while the marginal rate of return for each nitrogen fertilizer treatment with seed rate application was calculated as a change of benefit divided by change of variable cost and multiplied by100 (CYMMYT,1988).The cost of other inputs and production practice such as labor cost for land preparation, planting, weeding, crop protection and harvesting were assumed to remain the same or the difference among treatments was insignificant. However, economic recommendations were made by arranging interaction effect of nitrogen level and seed rate in order of decreasing the cost and then considering MRR between each treatment.Finally, the treatment with the highest net benefit and MRR was recommended for further production in the study area.

$$MRR = \frac{\Delta NB(NBb - NBa)}{\Delta TVC(TVCb - TVCa)} x100$$

Where, MRR = marginal rate of return in percentage, NB change in net benefits; TVC= Change in total variable cost.

4. RESULTS AND DISCUSSION

The results of nitrogen fertilizer level and seed rate on the performance of rice have been presented and discussed in this chapter. Results are shown in Tables 3 to 10, and analyses of variances are presented in Appendices 1 to 4.

4.1. Effect of Nitrogen Level and Seed Rate on Phenological Parameters of Upland Rice

4.1.1 Plant height

Analysis of variance revealed that main effect of different nitrogen level application highly significantly ($P<0.01$) influenced plant height. However, the interaction effect and main effect of seed rate did not significantly influence plant height (Appendix Table 1).Increasing the rate of nitrogen resulted in the increase of plant height.Further increase in nitrogen application rates resulted in significant increase in plant height with the successive increase in nitrogen rates. Nitrogen is an essential nutrient for plant growth and a constituent of chlorophyll, proteins and nucleic acids.Therefore,its application consistently increased plant height. The tallest plant height (87.4cm) was observed when 128kg N ha^{-1} was applied. Whereas the shortest plant height (68cm) was recorded from control treatments. An increase of nitrogen rate from 0 to 32 kg N ha^{-1} increased the plant height by about 3cm; increase of nitrogen rate from 0 to 64 kg N ha^{-1} increased the plant height by about (11.3cm) and further increasing the rate of nitrogen from,0 to 96 and 128 kg N ha^{-1} apparently increased height of the plants by about 15.5cm, and 19.4cm, respectively.

However, the rate of nitrogen at 0 and 32kg N ha^{-1} was not statistically different to plant height (68 and 71cm) respectively (Table 3).This might be nitrogen influences on cell division and cell elongation and thus increases plant height of the rice crop. This result is in line with Iqbal *et al*., (2015) Haque, and Haque,(2016) and Kumar *et al*. (2014) who reported that increased nitrogen level increased significantly the height of the rice crop. Similarly, Anil (2014) who noticed that different nitrogen levels significantly influenced the height of the rice plant.The results is in conformity with the findings by Buri *etal.* (2008); Ethan *et al.(*2012); Luka, (2013), and Eliakira *etal.* (2013) who observed increase in plant height of rice with increase in nitrogen rate.

4.1.2 Days to 50% heading

Analysis of variance revealed that the main effect of nitrogen application and seed rate highly significantly ($P<0.01$) influenced days to 50% heading of rice. However, the interaction effect of both factors did not significantly influence days to 50% heading of the rice (Appendix Table 1).The days to heading of rice was hastened under control as compared to the higher N rates.Thus,increasing the rate of nitrogen from 0 to 32 kg N ha^{-1} prolonged days to 50% heading by 2 days; also increasing the rate of nitrogen from 0 to 64 prolonged days to heading by about 6 days to heading while, further increasing the rate from 0 to 96 and 128kgNha^{-1} prolonged the days to heading by about 11 and 18 days respectively.Therefore,the most prolonged duration to heading (79.67 days) was recorded under plants grown at the rate of 128 kg N ha^{-1} whereas the shortest duration to heading (61.4days) was by plants grown at the control treatment. Generally, the number of days to heading recorded over all the fertilized plots was highly significant than the unfertilized plot (Table 3).

This might be because of the fact that high N supply increases the number and size of meristematic cells which leads to the formation of new shoots and promotes vigorous vegetative growth and development of the plants. This result agree with Anil (2013) reported that abundant supply of nitrogen delays 50% days to heading by promoting the vigorous vegetative growth of the plant. Similarly, Rakesh *et al*.,(2012) and Dechassa and Handiso, (2014) who was noted that days to 50% heading of crop was hastened under lower N rates compared to the higher N rates.
Regarding to seed rate highly significantly ($P\leq0.01$) influenced days to 50% heading of rice. The longest days to 50% heading (70.4 days) was obtained at seed 50kgha^{-1} followed by 60kg ha^{-1} seed rate required (68.8 days) to 50% heading .The shorter days to 50% heading was obtained from 70kg ha^{-1} seed (67.6 days) significantly earlier than other. The seed rate of 70 kg seed ha^{-1} also highly significantly hastened days to heading of rice compared to 50 and 60 kg ha^{-1} seed. Days to heading were 3 days earlier in the plots receiving 70kg ha^{-1} seed than 50kg seed ha^{-1}.

This might be because with lower seed rates plant competition for growth resources was lower than the competition at higher seed rates .The higher availability of nutrients and light resulted in more plant growth as compared to higher seed rates. In conformity with this Hoshikawa(1975b) reported that higher planting density has also been reported to hasten early heading and flowering in rice by affecting the heading order within a plant hill and population.Also In line with this result, Delessa *et al.* (2007) observed earlier heading and flowering of rice 101 and 105 days from the application of the highest seed rate of 125 kg ha^{-1}, Bunyatta (2012) also reported that heading and flowering were 5 days earlier in rice with 60 kg seed ha^{-1}. Similarly in wheat, Khalid *et al.* (2010) noted that heading was late by 3 days with lowest seed rate (100 kg ha^{-1}) compared to the highest seed rate (220 kg ha^{-1}).

4.1.3 Days to 50% flowering

Analysis of variance showed that the main effect of different nitrogen level application highly significantly ($P<0.01$) influenced days to 50% flowering.However,the interaction effect of both factors and main effect of seed rate did not significantly influence days to 50% Flowering of the rice (Appendix Table 1).Although higher seed rate of prompted early Flowering in rice it was not statistically different.On the other hand, nitrogen level had highly significantly affected days to flowering of rice. The days to the flowering of rice was hastened under lower N level as compared to the higher N rates. Thus, increasing the rate of nitrogen from 0 to 32 kg N ha^{-1} prolonged days to 50% flowering by 2days; also increasing the rate of nitrogen from 0 to 64 prolonged days to flowering by about 4 days to heading while, further increasing the rate from 0 to 96 and 128 kgN ha^{-1}prolonged days to flowering by about 8 and 13 days respectively. Therefore, the most prolonged duration to flowering (85.2days) was recorded under plants grown at the rate of 128 kg N ha^{-1} where as the shortest duration to flowering (72.2days) was by plants grown at the control.

This might be due to nitrogen involved directly or indirectly in the enlargement and division of new cells and production of tissues which in turn were responsible for the increase in growth characteristics particularly tiller numbers of the rice.Also in the same line with this result,Endris and Alemayehu (2010) showed that N rates up to 140 kg ha^{-1} significantly increased days to flowering and maturity of rice compared to the control (0kg ha^{-1}).Similarly,Dushyant *et al.* (2007) showed that nitrogen significantly increased days taken to 75% flowering and 225 kg N ha^{-1} took more days for flowering (73 days) than other lower N kg ha^{-1}.In contrast to this result, Sewenet *et al*.(2005);Meharie *et al.* (2010); and Missa *et al.* (2013) showed that as N levels increased to the optimum level, days to heading and flowering were earlier.

4.1.4 Days to 90% physiological maturity

Analysis of variance showed that main effect of nitrogen level application and seed rate had highly significantly ($P<0.01$) influenced days to 90% physiological maturity. However, the interaction effect of the two factors did not significantly influenced days to 90% physiological maturity of the crop (Appendix Table 1**.** Days to 90% physiological maturity of plants was delayed under increased nitrogen rates compared to the low nitrogen rates. Thus, increasing the rate of nitrogen from 0 to 32 kg N ha^{-1} prolonged days to 90% physiological maturity by about 3 days; increasing the rate of nitrogen from 0 to 64 kg N ha^{-1} prolonged days to 90% physiological maturity by about 4 days, while, increasing the rate of nitrogen further from 0 to 96 and 128 kg N ha^{-1} prolonged by about 8 and 17days respectively. Hence, the most prolonged duration to days to 90% physiological maturity (123.78 days) was recorded under plants grown at rate of 128 kg N ha^{-1} whereas, the shortest duration to maturity (107days) was recorded by plants grown at the control treatment. Generally, the number of days to maturity recorded over all the fertilized plots was significantly higher than the unfertilized plot (Table 3).

This might be due to increased nitrogen fertilizer application accelerated efficient uptake of nutrients and water as well as vegetative (efficient photosynthesis) growth leads to delayed flowering and crop maturity. This result agrees Marschener (1995), Tanaka *et al.* (1995) and Brady and Weil (2002) reported that N applied in excess than required delayed plant maturity. Also agree with Tanaka (1994) who reported that when nitrogen is applied in excess to rice, the sugar concentration in leaves reduces during early ripening stage and hence, inhibition occurs in the translocation of assimilated products to spikelets. Similarly, Tsedalu (2011) and Abraha, (2013) Haque *et al*.(2006) who noticed that application higher nitrogen rate took the longest days to mature.

Regarding to seed rate physiological maturity of plants under 70kg seed rate ha^{-1} was enhanced by about 4 days compared to 50kg ha^{-1} seed rate. This might be earlier maturity recorded at higher seed rates 70kg ha^{-1} could be due to competition for resources there by resulting in stress. According to Nwokwu (2015) reported that stress imposed might lead to early heading and maturity. In conformity with this result, Sewenet (2005) observed earlier physiological maturity of rice (4 days) with the increment of seed rate from 60-120kg ha^{-1}.Tekle and Wedajo (2013) also confirmed that days to physiological maturity were earlier by 6 days when the seed rate was increased from 80 to 100 kg ha^{-1} however, further increase in seed rate to 120 kg ha^{-1} increased the maturity by two days.

Table 3: Mean value of Phonological and growth Parameters of upland rice as influenced by the effects of nitrogen level and seed rate during 2017 main growing season at Kaffa zone.

Treatment	Plant height (cm)	Days to50% Heading	Days to 50% Flowering	Days to 90% physiology maturity
Seed rate/ha				
50	76.3^{a}	70.4^{a}	78.67^{a}	115.3^{a}
60	77.8^{a}	68.8^{b}	77.80^{a}	113.5^{ab}
70	79.5^{a}	67.6^{c}	76.67^{a}	111.6^{b}
LSD $_{(0.05)}$	NS	0.9	NS	2.16
N rate kg ha^{-1}				
0	68^{d}	61.4^{e}	72.2^{d}	107^{d}
32	71^{d}	63.4^{d}	74.3^{cd}	110.20^{c}
64	79.3^{c}	67.8^{c}	76.6^{c}	111.40^{c}
96	83.5^{b}	72.3^{b}	79.9^{b}	114.78^{b}
128	87.4^{a}	79.67^{a}	85.2^{a}	123.78^{a}
LSD $_{(0.05)}$	3.8	1.16	2.76	2.78
CV	5.01	1.78	3.68	2.54

Where, N: Nitrogen rate; LSD: least significant difference; Means sharing the same Superscript letter do not differ significantly at P = 0.05 according to the LSD test

4.2 Effect of Nitrogen Level and Seed Rate on Rice Yield and Yield Components

4.2.1 Number of effective tillers per meter square

The analysis of variance showed that a number of effective tillers m^{-2} were highly significantly (P <0.01) influenced by the main effect of nitrogen level and seed rate as well as affected by interaction of both factors (Appendix Table 2).The maximum number of effective tillers m^{-2} (357.33) was recorded in response to nitrogen applied at 96kgNha^{-1}and70kgha^{-1}seed rate followed by (329.33) tiller per m^{2} obtained from 96kgN ha^{-1}and 60kg ha^{-1}seed rate. Whereas the minimum number of effective tillers was obtained (156.33) from the control treatment and 70 kg ha^{-1}seed rate. This might be increasing nitrogen application rates also reflected significant increase in effective number of tillers m^2.These results were also in accordance with the findings of Haefele *et al.* (2008).Wani *et al.(*2016) reported that increase in dry matter with successive nitrogen levels might be due to the fact that increased nitrogen levels cause an increase in plant height, tiller m^{-2} which subsequently increase dry matter production.

This result also in agreement with Behera (1998) reported increased number of productive tillers $plant^{-1}$ with N application. Iqbal *et al.*(2015) reported that adequacy of nitrogen probably favored the cellular activities during panicles formation and development which led to increasing the number of effective tillers per m^{-2}.In contrast to this Dastan *et al. (*2012) reported excessive tillering caused by inadequate nitrogen fertilization reduced the percentage of fertile tiller; filled spikelet percentage and grain mass. According to Bozorgi *et al.(*2011)reported that over increasing of plant population beyond the optimum density results unnecessary stress on the plants and then affects tiller formation, sunlight interception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth and development of rice plant. Similarly reported that optimum planting density per unit area ensures plants to grow properly both in the upper ground and underground parts of the plant through better utilization of solar radiation and nutrients.

4.2.2 Number of Total Tiller per meter square

The analysis of variance revealed that number of total tillers m^{-2} was highly significantly ($P<0.01$) influenced by the main effects of nitrogen level and interaction effect of the both factors. However, total tillers m^{-2} did not significantly influenced by main effects of seed rate at (Appendix Table 2).The maximum number of total tillers per m^{-2} (420.67) was recorded in response to nitrogen applied at the rate of 96 kg N $ha^{-1}$and 70kgha^{-1} seed rate followed by (416) at 128kg N ha^{-1} and 60 kgha^{-1} seed rate. Whereas the minimum number of total tillers m^{-2} was obtained from the control and 70 kg seed rate (264.67) (Table 5)**.**This is mainly due to more nitrogen availability at higher levels of nitrogen that provided proper nutrition to the crop thereby increased tillering. Similar results were observed by Khalid *et al*. (2010) who demonstrated that different seed rates of wheat significantly increased the number of tillers, where in, the use of 220 kg seed ha^{-1} produced higher number of tillers.

In contrast to this result Sewenet (2005) observed a greater increase in the number of unfertile tillers due to initial huge/greater number of tillers m^{-2} reduced the number of fertile tillers (panicles) at 100kg seed ha^{-1},whereas the proportion of number of unfertile tillers to tillers m^{-2} was quite low mainly because of initial lower number of tillers m^{-2} at 120kg seed ha^{-1}.Also nitrogen fertilization significantly increases tillering in cereals, especially in rice (Fageria *et al.,*2003).This result agrees with Cassman *et al*., (1998) who claimed that a greater portion of the nitrogen requirement should be applied during active tillering when crop growth is rapid and nitrogen demand is high. Ahmad *et al.* (2005) also concluded that higher N rates with higher seedling density enhanced the number of tillers that directly contribute to the rice grain yield. According to Chopra (2004) reported increasing N rates might have improved photosynthetic rate and translocation of assimilate that might have resulted in the increase in number of tillers plant^{-1}.

4.2.3 Panicle length

The analysis of variance showed that panicle length was highly significantly (P<0.01) influenced by the main effect of nitrogen level as well as by interaction effect of both factors significantly but, not affected by the main effect of seed rate **(**Appendix Table 2 **).**Panicle length were significantly influenced by interaction effect of nitrogen and seed rate .The longest panicle length (24.2cm) was observed from 96kgNha^{-1}and70kgha^{-1} nitrogen level and seed rate respectively. While the shortest panicle length (14.06cm) was recorded from control and 70kgha^{-1}.This parameter markedly increases when N level and seed rate increase from 0 to 96kgN ha^{-1} and 50kg to 70kg ha^{-1} respectively. Further increasing the rate of nitrogen from 0 to 128 kg N ha^{-1} decrease panicle length to (17.70cm) (Table 5).This is might be nitrogen is associated with protoplasm synthesis and vigorous vegetative growth due to increased cell division and cell elongation and high amount of nitrogen application which leads to promotion of rapid growth of panicle length of rice crop. This result is agree with that of Mulugeta,(2006),Christopher *et al*.,(2012) who expresses that increase nitrogen rates increased the rice panicle length. In the same way,Yoseftabar ,(2013) who reported increment of panicle length with increasing rates of nitrogen fertilization (Anil *et al*,2014).Nitrogen application directly increased the chlorophyll content and leaf surface area which is turn increased photosynthetic process in rice.

4.2.4 Number of filled grain per panicle

The analysis of variance revealed that number of filled grain per panicle highly significantly ($P<0.01$) influenced by the main effect of nitrogen and interaction effect of both factors .However, this parameter did not significantly influenced by main effect of seed rate (Appendix Table 2).A number of filled grains per panicle varied highly significantly due to interaction effect nitrogen and seed rate.The highest number of filled grains per panicle (102) was recorded at 96kg N ha^{-1} and 70kg ha^{-1} seed rate followed by 96kg N /ha and 60kg /ha seed rate obtained (97.33). While, the small number of filled grains per panicle (59.66) was found at control treatment and 70kg seed rate.

This due to the sufficient supply of nitrogen might contribute to grain development, which probably increased the number of filled grains per panicle with increased nitrogen level up to optimum level but, further increase nitrogen rate decrease filled and increase spikelet sterility.

In the same way, Shakouri *et al*.(2012) who noticed that rice have a different response to different rate and timing of nitrogen, which is critical in terms of their effects on increasing number of filled grain. In contrast to this result obtained by Mannan *et al*.(2010) where the excessive amount of nitrogen application without at the right time of application reduced the carbohydrate content and resulted in an abnormal development of pollen grains, which causes increased spikelet sterility.

4.2.5 Grain yield (kg ha^{-1})

The analysis of variance showed that grain yield of rice was highly significantly ($P<0.01$) influenced by the main effect of nitrogen level and seed rate as well as by interaction of both factors (Appendix Table 2).Rice grain yield normally increased with increase in the level of nitrogen and seed rate however, further increase beyond the optimum requirement decline grain yield of rice. The highest grain yield (4755.2 kg ha^{-1}) was obtained from 96 kg N ha^{-1} and 70kg ha^{-1}.Whereas,lower grain yield recorded(2608.6kg ha^{-1}) was obtained from control plot and 70kg ha^{-1}seed.This might be due to the continuous and balanced supply of N into the soil solution to meet the required nutrients for physiological processes ,which in turn improved the yield.This result is consistent with that of Fageria and Baligar,(2001) who reported that N uptake in grain has positive significant associations with grain yield. Similarly agree with Wells and Faw 1978;

Nguu and De Datta,(1979) reported rice yield response to plant density has often been reported to be significantly influenced by the rate of N fertilizer application.

Similarly, Lin *et al.,(*2009) reported that nitrogen in combination with proper seeding densities play role for optimizing rice yields per unit area. Rice seedling density per hill and optimal nitrogen fertilization exercises a strong influence on rice growth and grain yield due to competitive effects both on the vegetative and reproductive development. Rice yield increment due to N levels and seedrate in this investigation is inconformity with Pandan *et al.*(1995), Rathi and Sharma(1996),Behera (1998), DAOFW (1998/99)and ANG(1998/99),who reported that nitrogen level and degree of spacing determined the growth of cereal crops and modified their characters, i.e. plant height, heading time, tiller number, panicle number, panicle length, panicle weight and yield. Net photosynthesis rate of C3 and C4 plants varies depending on the amount of nitrogen. According to IRRI (1965) high yields of rice are usually obtained by increasing nitrogen application and by dense planting. Malik *et al.*(1994) reported that the optimum N requirement of rice was 84 kg ha^{-1}.

According to Rathore *et al.*,1991;Thakur, 1993;Channaba savanna and Setty (1994) reported that increasing N levels increased grain yield by increasing the magnitude of yield attributes and the increase in yield attributes was the result of better nutrition and N uptake by rice crop (Rathore *et al.*,1991; Thakur, 1993) leading to greater dry matter production and its translocation to the sink (Dalal and Dixit, 1987).According to Singh and Pillai,1994;Singh *et al.*(1995) reported that increasing nitrogen and seed rate beyond the optimum requirement level of the crop resulted in decline of grain yield. Also increased nutrient uptake especially of N resulted in increased photosynthetic rate and increased plant growth resulted in higher translocation to sink and more grain yield of rice. According to Bah *et al*.(2009) application of N fertilizer at panicle initiation increased the number of grain/panicle,% of filled spikelets,1000-g grain weight and rice yield probably due to efficient N uptake.

Table 4: Mean values of Panicle length (cm) ,Filled grain/panicle, Total tiller/m2,Fertile tiller /m2,Grain yield /ha of upland rice as influenced by interaction effects of nitrogen level application and seed rate during the 2017 main growing season at Kaffa.

Seedrate kg/ha	N rate kg/ha	Effective tiller /m2	Total tiller/m2	Filled grain /panicle	Panicle length (cm)	Grain yield kgha^{-1}
50	0	188.67^{gh}	270 .00^{fg}	66.67^{gh}	15.73^{fg}	2786.1^{fg}
	32	214.67^{gf}	276.67^{fg}	81.33^{de}	18.73^{cde}	3170.4^{ef}
	64	220.00^{ef}	292.00 ^{e}	87.33^{cd}	18.23dce	3528.1^{de}
	96	247.67^{d}	400.66^{cd}	87.00^{cd}	19.06^{dc}	3547.2^{cde}
	128	241.33^{de}	406.667^{bc}	78.00^{fe}	16.70^{ef}	3389.9^{e}
60	0	172.33^{hi}	267.00^{fg}	65.67^{ghi}	15.40^{fg}	2739.8^{fg}
	32	258.67^{cd}	274.33^{fg}	72.33^{fg}	18.40^{dce}	3174.2^{ef}
	64	284.00^{c}	291.00^{e}	85.66^{dc}	19.40^{dc}	3979.1^{cb}
	96	329.33^{b}	390.67^{d}	97.33^{ab}	22.40^{ab}	4234.9^{b}
	128	282.67^{c}	416.00^{ab}	70.00^{g}	16.70^{ef}	3947.4^{cbd}
70	0	156.33^{i}	264.67^{g}	59.66^{i}	14.06^{g}	2608.6^{g}
	32	254.00^{d}	273.66^{fg}	82.33^{de}	18.10^{cde}	3170.4^{ef}
	64	281.00^{c}	278.67e^{f}	91.33^{bc}	20.13^{bc}	4123.5^{b}
	96	357.33^{a}	420.67^{a}	102.00^{a}	24.20^{a}	4755.2^{a}
	128	238.00d^{ef}	405.66^{bc}	60.333^{hi}	17.70^{def}	3962.7^{bcd}
	LSD$_{(0.05)}$	26.05	2.48	6.73	2.31	437.03
	CV	6.29	13.59	5.10	7.57	7.43

Where,N = Nitrogen rate; Means sharing the same superscript letter do not differ significantly at P = 0.05 according to the LSD test

4.2.6 Unfilled grains per panicle

The analysis of variance showed that a number of unfilled grain per panicle highly significantly (P<0.01) influenced by the main effects of N fertilizer level application however, their interaction and main effect seed rate did not influenced this parameter (Appendix Table 2).A number of unfilled grains per panicle was a reversal to that of filled grains at variable nitrogen levels. Thus highest number of unfilled grains per panicle was (11.44) at control treatment followed by (10.22) at 128kgNha^{-1} and the minimum number of unfilled grain was (5.56) at

96kgNha^{-1}.This is might be excessive as well as the low application of nitrogen fertilizer application causes a lower number of filled grains and a higher number of unfilled grains per panicle of rice. Haque and Haque,(2016) reported that optimum amount of nitrogen fertilizer with right time application on the other hand produces the maximum number of filled grains and a minimum number of unfilled grains per panicle. Reports from previous studies had shown that increased application of N enhanced vigorous vegetative growth resulting in reduced efficiency kernel filling as a result of increased competition of assimilates (Sewnet,2005;Missa,2013).V igorous vegetative growth caused heavy drain on soluble carbohydrate resulting in its reduced availability for spikelet formation (Hasegawa *et al.*,1994).The variability in number of filled or unfilled grains per panicle is dependent on many factors such as genotypes, cultural techniques and growing environment of the crop.

4.2.7 Thousand seed weight (gram)

The analysis of variance showed that the main effect of different N level application was highly significantly (P<0.01) influenced thousand seed weight. However, the interaction of the two factors and seed rate did not affect this parameter (Appendix Table 1).Thousand seed weight was highly significantly increased with increase in the rate of nitrogen application. Hence, increasing the rate of nitrogen from 0 to 32kg N ha^{-1} significantly increased thousand seed weight by about 7.6gm, also increasing the rate of N application from 0 to 64 significantly increased thousand seed weight by about 10 gm while, increasing the rate of N application from 0 to 96kg N ha^{-1} increased seed weight by about 12.6 gm however, further increasing N fertilizer to 128kg N ha^{-1} significantly decrease thousand seed weight. The maximum thousand seed weight was (33.29gm) obtained from plants supplied with 96kgN ha^{-1}.Whereas the minimum thousand seed weight (21.89gm) was obtained from the unfertilized plot (Table 4).

This might be application of nitrogen to optimum level increases thousand grain weight in rice crop because the proportion of filled spikelets at flowering is influenced by assimilate supply. In contrast to this Tanaka and Takahashi *et al.,(*1995) showed that increase in number of spikelets per panicle and vigorous vegetative growth owing to high nitrogen fertilizer application induces competition for carbohydrate available for grain filling and spikelet formation which in turn reduces the grain weight because of insufficient supply of carbohydrate to the individual grains. This result is in agreement with that of Tsedalu (2011) who reported that the 1000 seed weight increased with the increase of nitrogen rate as nitrogen has a profound effect on seed development. Similar results also found by other authors Iqbal *et al*.(2015) who reported that the effect of different nitrogen level on 1000 grain weight of rice was significant.

4.2.8 Harvest index

Harvest index is the ratio of economic yield to total dry weight. Analysis of variance revealed that main effect of nitrogen level application highly significantly ($P<0.01$) influenced harvest index; however interaction of both factors and the main effect of seed rate did not influenced this parameter (Appendix Table 2).Harvest index was highly significantly increased with increase in the rate of nitrogen application. Hence, increasing the rate of nitrogen from 0 to 32 kg N ha^{-1} significantly increased harvest index by about 5.6%, increasing the rate of N application further from 0 to 64 significantly increased harvest index by about 8.8% while, increasing the rate of N application from 0 to 96kg N ha^{-1} increased harvest index by about 11.2 however, further increasing N fertilizer to128kg N ha^{-1} significantly decrease harvest index. The maximum harvest index(39.91%) was obtained from plants supplied with 96kgNha^{-1}.Whereas the minimum harvest index (28.71%) was obtained from the unfertilized plot (Table 4).This might be increasing N levels increased grain yield by increasing the number of yield attributes.

This result is in agreement with Kanungo and Rout (1994) and Panda *et al.* (1995) reported that increment of harvest index could be achieved with moderate doses of N. Similar result were reported by (Sawires, E.S. *et al.*,2000) who reported that harvest index, dry weight and shoot length increased significantly with increasing levels of nitrogen fertilization. Also observed that harvest index increased up to a certain level of N and decreased with further increase in N rate. In contrast to this study Mulugeta (2000) indicated that N had a marked negative effect on harvest index of rice due to the fact that growth promoted by N application resulted in low harvest index by favoring more dry matter accumulation in the vegetative part rather than in the rice grain.

4.2.9 Biomass yield

The analysis of variance showed that main effect of seed rate and N fertilizer application was highly significantly ($P<0.01$) influenced biomass yield of rice. However, interaction of both factors did not influenced this parameter (Appendix 2).The highest biomass yield obtained from

N fertilizer rate 128kg/ha about (12935.6kg/ha) and the lowest obtained from control treatment (5662.3kg/ha).This might be biomass yield increased significantly with the increase in rate of nitrogen application.The results are in conformity with Barnes(1985),Sudhakar *et al.* (1987), Hari*et al*.(1997),Behera(1998) and DAOFW (1998/99),Dalal and Dixit (1987) reported that increasing rate of N increased dry matter weight of rice by enhancing N uptake. Such increase in dry matter accumulation of rice actually accentuated from increase in length of leaves, elongation of stem/tillers and panicles or in general increased vegetative growth of plants (Kumbhar and Sonar, 1980). In addition, Zia *et al*.(1992) observed 40% increase in biomass with the application of 80 to 150 kg N/ha to rice.

Regarding to seed rate highly significantly ($P<0.01$) influenced biomass yield of rice. The highest biomass yield obtained with 70kg ha^{-1} seed about (10488.7kg /ha) and lowest from 50kgha^{-1} seed rate (8169.1kg/ ha).Variation in biological yield might be due to variation in growth and yield attributing characters and biomasses yield increase with the increasing seed rate. Kanda and Kakizaki(1957) observed a logarithmic relationship between plant population and production of total dry weight per unit area. Yamada (1961) reported that the total dry matter and grain weight per unit area increased with a decrease in spacing up to a certain extent after which there was no change or a decrease depending on the characters of the variety. This, in other way, implied that higher planting density within limit might produce more total dry matter per unit area.

4.3.0 Straw yield

Analysis of variance revealed that straw yield was affected by the main effect of nitrogen level and seed rate highly significantly ($P<0.01$) influenced straw yield of rice. However, did not influenced by interaction effect of both factor (Appendix2).The highest straw yield (8509.4kgha^{-1}) was obtained in response to applying 128kg Nha^{-1}. Where as the lowest straw yield (3381.2kg ha^{-1}) was obtained from control treatment**.** This might be due to increasing N rate was reported to increase dry matter accumulation in rice by enhancing N uptake as well as increasing dry matter is attributed to increase in length of leaves, elongation of stem and panicles, or in general to increase in vegetative growth of the plant.

This result is in agreement with Rahaman *et al*.,(2007) reported that, the influence of nitrogen application in vegetative growth in terms of plant height and number of tillers, which further increased the straw yield. On the other hand straw yield was highly significantly ($P < 0.01$) influenced by the main effect of seed rate.The highest straw yield obtained (6387.4 kg/ha) from 70kgha^{-1} seed rate. Where as the lowest straw yield (4982.4 kg/ha) from 50kg/ha seed rate. This might be due to implied that higher planting density within limit might produce more total dry matter per unit area. Singh *et al*.,(2003) and Uddin *et al*.(2011) reported this might be due to higher plant population as well as due to shading of leaves of one plant to another, since the shaded plants show more vegetative growth.

Table 5: Mean Value of Harvest index (%),1000seed weight(g),Unfilled grain/panicle, Biological yield (kg/ha), Straw yield of Upland rice as Influenced by Main Effects of Nitrogen Level and Seed rate During the 2017 Main Growing Season at Kaffa zone.

Seed rate (kg/ha)	Harvest Index	1000Seed weight(g)	Unfilled grain/panicle	Biological yield(kg/ha)	Straw yield
50	32.70 ^{a}	28.29^{a}	8.47^{a}	8169.1^{c}	4982.4^{c}
60	34.43^{a}	28.92^{a}	8.53^{a}	9354.1^{b}	5829.4^{b}
70	35.95^{a}	28.87^{a}	9.47^{a}	10488.7^{a}	6387.4^{a}
LSD $_{(0.05)}$	NS	NS	NS	376.03	360.54
N rate kg ha^{-1}					
0	28.71^{d}	21.89^{d}	11.44^{a}	5662.3^{e}	3381.2^{e}
32	34.34^{bc}	29.46^{bc}	9.22^{b}	6713.4^{d}	4008.0^{d}
64	37.47^{ab}	31.84^{ab}	7.67^{c}	9933.1^{c}	6028.7^{c}
96	39.91^{a}	33.29^{a}	5.56^{d}	11441.9^{b}	6738.0^{b}
128	31.38^{cd}	26.99^{c}	10.22^{ab}	12935.6^{a}	8509.4^{a}
LSD $_{(0.05)}$	3.33	2.66	1.50	485.46	465.46
CV	10.04	9.62	17.68	5.38	8.40

Where, N = Nitrogen rate; Means sharing the same superscript letter do not differ significantly at P = 0.05 according to the LSD test

4.3 Concentration of Nitrogen in the Grain and Straw and N Uptake

4.3.1 Straw nitrogen concentration

The analysis of variance showed that Straw nitrogen content at maturity was highly significantly ($P<0.01$) influenced by the main effect of N level and interaction effect of both factors significantly ($P<0.05$).However, did not significantly affected by main effect of seed rate (Appendix Table 3).The maximum straw nitrogen content (0.62%, 0.58% and 0.54%) were obtained from (60, 50 and 70 kg ha^{-1}) seed ha^{-1} with 128kg Nha^{-1} respectively. Whereas, the minimum values(0.18%)were obtained from70kgha^{-1}seedratewithcontrol treatment.Generally,the straw nitrogen content was varied from 0.62-0.18%(Table 6).This might be high amount of nutrient applied enhanced vigorous vegetative growth and high amount nitrogen content could be accumulated in straw which does not translocate to grain. This result agrees with Kaushal *et al*. (2010) who reported that significant increase in nitrogen content of straw with increasing rate of N application.

4.3.2 Grain nitrogen concentration

The analysis of variance showed that nitrogen content in the grain at maturity was highly significantly ($P<0.01$) affected by the main effect of N rate and interaction effect of both factor. However, did not significantly affected by main effect of seed rate(Appendix Table 3).This might be the content of N in the grain increase with increasing the rate of N application.The maximum grain nitrogen content(1.55 and 1.53) obtained in response to 128kg N ha^{-1} with 70kg ha^{-1}and 96kg N ha^{-1} with 60kg ha^{-1} nitrogen and seed rate respectively.The lowest values (0.34 and 0.38) obtained from 70kg ha^{-1} seed with control and 60kg ha^{-1} seed rate with control treatment (Table 6) respectively. Generally, the grain nitrogen concentration was varied from 1.55- 0.34.This might be due to the increased rate of N mobilization to the grain at grain filling stage influenced by high rates of N application. This implies a positive response of grain N content to increased N rate.

Furthermore, increased N concentration in the grain was due to the increased N application might have increased the concentration of N in the soil and thus probably leads to more uptake of N from the soil. This result agrees with sokat (2006) and sewnet (2005) who reported the increased grain N concentration with increasing rate of N application. Similarly, Tari and Amiri,(2015)who reported that nitrogen application at three physiological stages of rice (more ratio of nitrogen was applied at the early heading stage and the rest was applied at other basic and tillering stages) could increase nitrogen content in above-ground organs.

4.3.3 Straw nitrogen uptake

The analysis of variance showed that Straw nitrogen uptake at maturity was highly significantly ($P<0.01$) influenced by the main effect of N rate and by the interaction effect of both factor as well as by the main effect of seed rate significantly ($P<0.05$) influenced by this parameter (Appendix 3).The maximum straw N uptake (60.29and 53.6) obtained from 70 and 60 kg ha^{-1} seed with 128kgNha^{-1}seed rate and nitrogen application respectively, which have comparable result each other. Whereas, the minimum was (6.33, 6.55 and 7.06) obtained form (70,60 and 50kg ha^{-1}) seed rate with control treatment respectively. This might be nitrogen application provided better conducive condition for better growth and` yield attributes through simply of more photosynthesis. This also may be associated with a maximum yield of straw (Fageria *et al.*, 2009).

This result is in line with the findings of Goldeyes *et al.* (2004) and Muurinen (2007) who reported a significant increase in straw nitrogen uptake with increased N rates. Similarly, Tayefe *et al*., (2011) observed that the N ratio in straw enhanced with increasing N application and it led to rice plant uptake N excessively.TG (2014) who noticed that nitrogen application at sowing, at tillering and at panicle initiation stage recorded significantly higher uptake of nitrogen at higher nitrogen level. In contrast to this Fageria *et al* (2005) reported that diminishing trend of NUE at higher N rates pointed out that rice plants are unable to absorb or utilize N at higher rates or the rate of N uptake by plant cannot keep pace with the loss of N.

4.3.4 Grain nitrogen uptake

The analysis of variance showed that grain N uptake was highly significantly ($P< 0.01$) influenced by the main effect of nitrogen level and seed rate as well as by interaction effect of both factor (Appendix Table 3).The maximum grain N uptake (68.30, 65.16 and 63.22 kgN ha^{-1}) was obtained from 70 and 60 kgha^{-1} seed rate with 96kg Nha^{-1}nitrogen level respectively.The latter obtained from 70 kgha^{-1} seed with 128kg Nha^{-1} which have comparable value to each other. Whereas, the minimum grain N uptake (9.017 kgNha^{-1}) was obtained from 70kg seed with control treatment. This might be due to the conjunctive and harmonizing effects of right dose and the right time of nitrogen feeding to the rice crop might have resulted in better root activity, thereby enhancing the absorption of applied nutrients. According to Patel and Thakur (1997) reported that additional nitrogen supply by fertilization during the maximum growth period of crop plants might have favored the higher nitrogen uptake by crop plants. Similarly, TG (2014) and Kaushal *et al*.,(2010) who reported that application of nitrogen at sowing, tillering and at panicle initiation stage recorded significantly higher uptake of nitrogen at higher nitrogen level. Application of some extra N through increased levels definitely increased the concentration of N in soil and led to greater absorption of nutrients, which ultimately resulted in vigorous growth of rice in terms of higher dry matter accumulation and enhanced the total uptake. At lower doses of N concentration and uptake of N in the tissues and grain became lower. Similarly, Borrell *et al.* (1998) reported that at low level of N availability, tissue concentration and uptake of N became low and grain yield of rice was proportional to N uptake.

4.3.5 Total nitrogen uptake

Total nitrogen uptake was highly significantly ($P<0.01$) affected by the N level and seed rate. Also interaction effect of the both factors significantly ($P< 0.05$) influenced the total N uptake (Appendix Table 3).The highest total nitrogen uptake (123.51kg N ha^{-1}) was recorded from 128 kg Nha^{-1} and 70 kg ha^{-1} nitrogen and seed rate respectively. Whereas the minimum total nitrogen uptake (15.56,16.87 and 20.16 kg N ha^{-1}) was recorded at 70,60 and 50 kg ha^{-1} seed rate with control treatment respectively. This result in agreement with (Kumar and Rao,1992; Panda *et al*.,1995;Singh *et al.*,1995) reported that uptake and concentration of N in the important tissues of rice like leaves, grain and straw usually increase by increased level of fertilizer N. In contrast to this Kumar and Roan,(1992);Panda *et al.(*1995) reported that N content of rice grain gradually decreases when the higher sowing density and N fertilization was applied. In addition to this Nayak *et al*.(2015) reported that increase in total uptake of nitrogen with an increase in nitrogen application due to the cumulative effect of an increase in grain and straw yield as well as increased nitrogen content in grain and straw. This result in line with Tayefe *et al*,2011, Halder *et al*.,(2008) and Singh *et al*.,(2013) who reported that total N uptake increased with increasing in N fertilizer contents. Also results by TG, (2014) who reported that application of nitrogen as at sowing, tillering and at panicle initiation recorded significantly higher uptake of total nitrogen by rice crop.

Table 4: Mean values straw nitrogen content, grain nitrogen content, straw nitrogen uptake (kg ha-1),grain nitrogen uptake (kg ha-1) and Total nitrogen uptake (kg ha-1) of rice as affected by interaction effect of nitrogen level and seed rate during the 2017 main growing season at Kaffa.

SR kg/ha	N kg/ha	STNC%	GNC%	SNU	GNU	TNU
50	32	0.33^{de}	0.69^{defg}	11.78^{gh}	20.32^{gf}	32.12^{gh}
	64	0.35^{cde}	0.93^{cd}	16.81^{fg}	32.60e	49.41^{f}
	96	0.44^{cd}	0.88^{cde}	26.41^{e}	31.42^{e}	57.83^{f}
	128	0.58^{ab}	1.25^{bc}	43.60^{c}	42.91^{cd}	86.51^{d}
60	32	0.31^{efd}	0.76^{def}	11.57^{gh}	24.21^{f}	35.78^{g}
	64	0.44^{cd}	1.05^{cd}	29.09^{de}	41.94^{cd}	71.03^{e}
	96	0.31^{efd}	1.53^{a}	21.19^{ef}	65.16^{a}	86.35^{d}
	128	0.62^{a}	1.15^{bc}	53.68^{ab}	45.48^{c}	99.15^{bc}
70	32	0.19^{fg}	0.52^{efg}	8.77^{gh}	16.74^{gh}	25.51^{hi}
	64	0.24^{efd}	0.88^{cde}	15.57^{fg}	36.86^{de}	52.43^{f}
	96	0.47^{bc}	0.90^{cde}	37.02^{cd}	68.30^{a}	105.32^{b}
	128	0.54^{ab}	1.55^{a}	60.29^{a}	63.22^{ab}	123.51^{a}
LSD$_{(0.05)}$		0.13	0.37	8.29	6.43	10.12
CV		21.62	23.53	20.80	10.61	10.07

Where,=Nitrogen rate, SR: Seedrate ,grain nitrogen concentration(GNC),strawnitrogen concentration (STNC),grain nitrogen uptake (kg ha^{-1}*)(GNU)and straw nitrogen uptake (kg ha*$^{-1}$*)(SNU), Total nitrogen uptake (kg ha*$^{-1}$*) (TNU).*

4.4 Nitrogen Use Efficiency

4.4.1 Agronomic N use efficiency

Agronomic use efficiency is the amount of additional yield produced for each additional kg of N level applied (Mengel and Kirkby,2001).The analysis of variance indicated that agronomic N use efficiency was influenced by the main effects of N level and seed rate as well as by interaction effect of both factors highly significantly(P<0.01) influenced this parameters (Appendix Table 3).This result indicated that agronomic N use efficiency were highly significantly affected by interaction effect of nitrogen level and seed rate.The maximum agronomic N use efficiency obtained (23.63kg grain yield kg^{-1} N) from 64 kg N ha^{-1} with 70 kg/ha statistically similar with (22.37kg grain yield kg^{-1} N) recorded from 96kg N ha^{-1} and 70 kg/ha. While, the lowest agronomic efficiency (4.6kg grain yield kg^{-1}N) obtained from 32 kg Nha^{-1} and 50 kg/ha seed rate. This might be the highest agronomic use efficiency was obtained due to yield increment per unit N applied is high because of reduced losses and increased uptake of N. According to Fageria *et al.(*2006) showed that for the efficient management of N in the cropping systems, adequate rate, appropriate source and timing of application during crop growth cycle play an important role. Also Lin *et al*.(2009) reported that nitrogen in combination with proper seeding densities may play its role for optimizing rice yields per unit area. Similarly Tari, and Amiri,(2015) reported that maximum agronomic use efficiency of nitrogen was obtained when the nitrogen rate increase from 40 to 120 kg ha^{-1}.

4.4.2 Physiological N use efficiency

Physiological N use efficiency is defined as the biological yield obtained per unit of nutrient uptake (Fageria, 2009).The analysis of variance showed that Physiological N use efficiency was highly significantly ($P<0.01$) influenced by the main effect of N fertilizer level and seed rate application as well as the interaction effect of both factor (appendix Table 3).Physiological N use efficiency of rice influenced highly significantly by interaction effect of nitrogen level and seed rate. As the level of N increased from 0 to128kg$Nha^{-1}$and seed rate from 50 to 70kg ha^{-1}, physiological N use efficiency consistently decreased across some treatment application except 64 kg N ha^{-1} applied with 50kgha^{-1} seed rate which showed to some extent increment. The highest physiological N use efficiency were recorded (138.75 and 135.65)from 64 kg N ha^{-1} with 50 kg ha^{-1} and 96kgNha^{-1}with50 kg ha^{-1} seed rate respectively. Whereas, the lowest physiological N use efficiency(47.11)obtainedfrom128kgNha^{-1}and70kgha^{-1}followedby(50.97) obtained from96kgNha^{-1}and70kgha^{-1} nitrogen and seed rate respectively(Table 7).This result in agreement with the results of Fageria *et al*.,(2009) demonstrated that, with increasing application of nitrogen fertilizer from 50 to 200 kg ha^{-1},the physiological N use efficiency of nitrogen decreased. This might be at greater N rates indicated that rice plants could not absorb or utilize N at greater rates or N losses exceeded the rate of plant uptake. Eagle *et al*. (2000) reported that N-use efficiency in rice, which has both physiological and soil N supply components, decreased with increases in soil N supply. Similarly, Tari and Amiri (2015) who reported that maximum physiological nitrogen use efficiency was achieved by applying 40kgNha^{-1}when nitrogen applied at the time of sowing, maximum tillering stage and in panicle initiation stage. In contrast to this result Creswell and Godwin (1984) observed that higher physiological efficiency due to higher level of N application.

4.4.3 Apparent N recovery efficiency

The analysis of variance showed that apparent nitrogen recovery efficiency was highly significantly ($P<0.01$)influenced by the main effect of N level and seed rate as well as by interaction effect of both factor (Appendix Table3).Apparent nitrogen recovery efficiency decreased with the increase in the rate of nitrogen application. The highest amount of apparent nitrogen recovery (93.50%) was obtained from 70kg ha^{-1} and 96 kg N ha^{-1}.While the lowest apparent nitrogen recovery obtained (31.07%) from 70kg ha^{-1} and 32 kg N ha^{-1} seed and nitrogen level respectively (Table7).This result conform with Gunri *et al.,* (2004) who reported that apparent nitrogen recovery percent was significantly higher at a lower level of N and decreased Significantly at higher levels of nitrogen. Similarly, Lopez-Bellido *et al*.,(2005) reported that recovery of N applied was determined based on measurements of N uptake in the aerial plant biomass.

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Table 5: Mean of Agronomic use efficiency, physiological efficiency and apparent recovery efficiency of rice as affected by nitrogen level and seed rate during the 2017 main growing season at Kaffa zone.

SR kg/ha	N kg/ha	ANUE	PNUE	ARE %
50	32	4.63^{g}	108.56^{dc}	37.32^{fg}
	64	10.93^{ef}	138.75^{a}	45.69^{efg}
	96	8.57^{f}	$135. 65^{ab}$	39.24^{fg}
	128	4.70^{g}	101.42^{d}	37.82^{fg}
60	32	13.567^{ed}	66.43^{ef}	59.08^{de}
	64	19.20^{b}	88.99^{de}	84.61^{bc}
	96	15.50^{cd}	100.00^{d}	72.37^{cd}
	128	9.40^{f}	97.07^{d}	71.23^{cd}
70	32	17.53^{bc}	131.04^{abc}	31.07^{g}
	64	23.63^{a}	110.54^{bcd}	57.61^{de}
	96	22.37^{a}	50.97^{f}	93.50^{a}
	128	10.53^{f}	47.11^{f}	84.33^{bc}
	$LSD_{(0.05)}$	2.78	25.80	15.49
	CV	15.59	19.51	18.53

Where, N=Nitrogen rate, SR: seed rate, ANUE: Agronomic N Use Efficiency, PNUE: Physiological N Use Efficiency, ARE %: Apparent Recovery Efficiency (ARE %), Means Sharing the same letter do not differ significantly at P = 0.05 according to the LSD test

4.5 PARTIAL BUDGET ANALYSIS

Partial budget and MRR was calculated by following procedure described CYMMYT (1988).The highest adjusted grain yield (4279.71kg ha^{-1}) with the highest net benefit (39006 birr ha^{-1}) was recorded due to 70kg ha^{-1} seed rate with application of 96 kg N ha^{-1}(Table 8),while the lowest (24,175birr ha^{-1}) with the least cost (900 birr ha^{-1}) were obtained from the combination of 0 kg N ha^{-1} and 50kg ha^{-1}seed rate. In order to recommend the present result for producers it is necessary to estimate the minimum rate of return acceptable to producers in the recommendation domain. According to CIMMYT(1988),the minimum acceptable marginal rate of return (MRR %) should be between 50 and 100%.Therefore,the most attractive rate of return with higher benefits was obtained with the combination 70kg seed rate with application of 64kgN ha^{-1} recommended for the farmers. In conformity with this result Wajid *et al* .(2003) recorded highest MRR % (488.25) and a net income of (52831.00 birr ha^{-1}) economic profit, for wheat crop using 120 kg ha^{-1} seed rate and fertilized with 120 kg N ha^{-1}.Similarly, Missa,(2013) reported that highest net benefit of wheat(Birr20,800 ha^{-1}) from the combined application of the highest 69 kgNha^{-1}and75kgseedha^{-1}with respective highest marginal rate of return 889%.

Table 6: Partial budget analysis nitrogen level and seed rate on upland rice yield

SR kg/ha	N rate kg/ha	Average grain yield kg/ha	Adjusted grain yield kg/ha	Gross farm gate price (ETB ha^{1})	Application cost of fertilizer and seed (ETB ha^{-1})	Seed cost (ETBha^{-1})	Fertilizer cost(ETB ha^{-1})	Total variable cost(ETBha^{-1})	Net benefit (ETBha^{-1})	Marginal rate of return (%)
50	0	2786.1	2507.49	25075.0	150	750	0	900	24,175	-
	32	2941.2	2647.08	26470.0	450	750	730	1930	24,540	D
	64	3528.1	3175.29	31752.9	500	750	1461	2711	29042	577
	96	3547.2	3192.48	31925.0	550	750	2191	3491	28,434	D
	128	3389.87	3050.88	30508.8	600	750	2922	4272	26237	D
60	0	2739.8	2465.82	24658.2	200	900	0	1100	23558	D
	32	3174.2	2856.78	28567.8	450	900	730	2080	26487	299
	64	3979.06	3581.16	35811.6	500	900	1461	2861	32951	828
	96	4234.9	3810.51	38105.1	550	900	2191	3641	34,464	194
	128	3947.37	3552.63	35526.3	600	900	2922	4422	31105	D
70	0	2608.6	2347.74	23477.4	250	1050	0	1300	22,117	288
	32	3170.37	2853.37	28533.7	450	1050	730	2230	26303	450
	64	4123.5	3711.15	37111.5	500	1050	1461	3011	34101	999
	96	4755.23	4279.71	42797.1	550	1050	2191	3791	39006	629
	128	3962.73	3565.98	35659.8	600	1050	2921.73	4572	31088	D

kg/ha = kilogram per hectare ;SR = Seed rate, 100kg rice Seed = 1500birr ; 100kg urea fertilizer =1050 birr ; Price of rice grain = 10 birr/kg and Labor cost = 50 birr/ person/day ; N rate = Nitrogen rate ; Gross Farm gate price (Return from Grain yield) = Price /kg yield in kg and Net benefit = gross benefit – Total cost.*

4.6 PEARSON’S CORRELATION COEFFICIENT

4.6.1 Correlation of Grain Yield with Yield and Yield Components of Upland Rice

Pearson’s correlation coefficient analysis was done to show the association between grain yield and yield components of upland rice (Table 9).The results indicated that highly significant and positive correlation was found for grain yield with all yield components i. e with filled grain per panicle (r= 0.61**),number of total tillers per m^2 (r= 0.63$^{**)}$,straw yield (r= 0.74**),biological yield (r=0.80**),grain harvest index(r=0.63**),number of effective tillers per m^2(r=0.82**). Furthermore, the Phenological as well as growth parameters were also showed positive and significant association with grain yield; viz: days to heading(r=0.52**), days to flowering(r= 0.45**) , days to maturity (r = 0.37** plant height (r=0.73**)and panicle length (r=0.70**).

Besides, the positive and highly significant association was found between grain yield and phonological traits, growth and yield components among themselves and with traits of interest. Generally, the strong and positive association was observed between grain yield and yield components. This indicated the strong contribution of traits to increased grain yield .This result in agreement with the investigation of (Mekbib, and Jember, 2015, Akinwale. *et al*., 2011, and Ranawake and Amarasinghe, 2014) who reported significant and highly positive correlation of grain yield with yield components, filled grain per panicle, number of total tillers, effective tillers, days to heading, days to flowering, days to maturity and plant height.

Table 7: Pearson's correlation coefficient between agronomic traits

	TT	ET	PH	PL	HI	TSW	DH	DF	DM	GY	BYD	STY	FG
TT	1.00	0.56**	0.80**	0.37*	0.25^{ns}	0.30*	0.87**	0.77**	0.74**	0.63**	0.81**	0.80**	0.25^{ns}
ET		1.00	0.58**	0.81**	0.66**	0.69**	0.41**	0.36*	0.27^{ns}	0.82**	0.66**	0.59**	0.72**
PH			1.00	0.45**	0.28^{ns}	0.42**	0.78**	0.72**	0.68**	0.73**	0.89**	0.85**	0.31*
PL				1.00	0.66**	0.77**	0.17^{ns}	0.15^{ns}	0.07^{ns}	0.70**	0.43**	0.34*	0.79**
HI					1.00	0.68**	0.09^{ns}	0.02^{ns}	-0.03^{ns}	0.63**	0.39**	0.33*	0.74**
TSW						1.00	0.23^{ns}	0.24^{ns}	0.13^{ns}	0.67**	0.40**	0.35*	0.74**
DH							1.00	0.87**	0.86**	0.52**	0.81**	0.83**	0.14^{ns}
DF								1.00	0.83**	0.45**	0.74**	0.72**	0.09^{ns}
DM									1.00	0.37*	0.64**	0.71**	0.02^{ns}
GY										1.00	0.80**	0.74**	0.61**
BYD											1.00	0.95**	0.30*
STY												1.00	0.20^{ns}
FG													1.00

*Ns=not significant, * and ** indicates significant difference at probability levels of 5% and 1%, respectively. DH: 50% days to heading, DF: 50% days to flowering, DM: 90% days to physiological maturity, PH: plant height, PL: panicle length, TSW: thousand seed weight, TT: total tillers, ET: effective tillers, FG: filled grain, GY: grain yield, BY: biomass yield, STY: straw yield, HI: harvest index.*

4.6.2 Correlation Between Grain Yield and N uptake of Upland Rice

The grain yield was highly significantly and positively associated with grain nitrogen uptake ($r=0.88^{**}$), straw N uptake ($r= 0.57^{**}$) and total nitrogen uptake ($r= 0.80^{**}$) (Table 10).This has clearly indicated that the highest contribution of absorbed nitrogen content in the rice plant for the increment of grain yield in upland rice. This result is in agreement with Fageria *et al.*,(2010) who obtained highly significant and positive association between grain yield and nitrogen uptake in upland rice. Further more to this relationship between plant N uptake and yield related traits also indicated positive and significant relationship with grain N uptake ($r= 0.88^{**}$) straw N uptake(0.57^{**})total N uptake($r=0.80^{**}$).

The positive and highly significant association was also observed between grain N uptake and other yield-related traits of upland rice, a number of filled grain per panicle($r=0.60^{**}$),total tillers number($r=0.63^{**}$)effective tiller ($r=0.90^{**}$)and biological yield($r=0.80^{**}$).Likewise, the straw N uptake also showed positive and significant association with grain yield ($r=0.57^{**}$), biological yield ($r= 0.83^{**}$),total tiller number ($r=0.81^{**}$), effective tiller ($r=0.76^{**}$) and panicle length ($r= 0.17^{**}$).The result showed that interrelationship between N uptake in grain and increased grain yield.This result is in agreement with the earlier finding of Mekbib, and Jember, (2015) who reported that significant and positive correlation between grain N uptakes with biological yield. The strong association between grain yield and nitrogen uptake indicated the enhancement of N uptake in grain and shoot at maturity can improve the upland rice yield.

Table 8: Correlation between Grain yield and N uptake of upland rice

	TT	ET	PL	TSW	GY	BY	STY	FG	SNU	NGU	TNU
TT	1.00	0.56^{**}	0.37^{*}	0.30^{*}	0.63^{**}	0.82^{**}	0.81^{**}	0.25^{ns}	0.81^{**}	0.79^{**}	0.86^{**}
ET		1.00	0.81^{**}	0.70^{**}	0.82^{**}	0.66^{**}	0.59^{**}	0.72^{**}	0.9^{**}	0.76^{**}	0.64^{**}
PL			1.00	0.76^{**}	0.70^{**}	0.43^{**}	0.34^{*}	0.79^{**}	0.17^{ns}	0.64^{**}	0.46^{**}
TSW				1.00	0.67^{**}	0.40^{**}	0.35^{*}	0.74^{**}	0.17^{ns}	0.57^{**}	0.42^{**}
GY					1.00	0.80^{**}	0.74^{**}	0.60^{**}	0.57^{**}	0.88^{**}	0.80^{**}
BY						1.00	0.95^{**}	0.30^{*}	0.83^{**}	0.85^{**}	0.91^{**}
SY							1.00	0.20^{ns}	0.90^{**}	0.82^{**}	0.92^{**}
FG								1.00	-0.04^{ns}	0.46^{**}	0.26^{ns}
SNU									1.00	0.72^{**}	0.91^{**}
NGU										1.00	0.94^{**}
TNU											1.00

*Ns=not significant, * and ** indicates significant difference at probability levels of 5% and 1%, TT: total tillers, ET: effective tillers ,PL: panicle length, TSW: thousand seed weight, FG: filled grain, GY: grain yield, BY: biomass yield, STY: straw yield, GNU: grain nitrogen uptake, SNU: straw nitrogen uptake, TNU: Total nitrogen uptake.*

5. SUMMARY AND CONCLUSION

Rice is among the most important cereal crops grown in different parts of Ethiopia as a food crop. However, its productivity is constrained by low soil nitrogen due to losses of mineralized nitrogen during the growing rainy seasons and using non-optimal seed rate. The use of appropriate nitrogen rate and seed rate is critical to production and productivity of rice. A field experiment was conducted with the purpose of determining an optimum rate of N fertilizer and seed rate for upland rice under Gojeb condition. The experiment consisted of five nitrogen rates (0, 32, 64, 96 and 128 kg N ha^{-1}) and three seed rate (50,60 and 70 kg ha^{-1}).It was laid out by using Randomized Complete Block Design (RCBD) in a factorial arrangement with three replications. The result showed that main effect of nitrogen level and seed rate had a significant effect on rice phenological characters i.e. days to heading, flowering and maturity.

The longest days to heading and maturity was recorded at the highest rate of N fertilizer (128 kgNha^{-1}) and lower seed rate(50kgha^{-1})application while the earlier days recorded from control treatment and higher seed rate(70kg ha^{-1}).In the same way, the increased N rate application had significantly increased days to flowering and height in rice. The longest days to heading, flowering, maturity and plant height were found at 128 kg N ha^{-1}, while the lowest at control treatment. In addition, result of the experiment indicated that nitrogen level had a significant effect on rice yield and yield component ie. Harvest index (%), 1000 seed weight (g), unfilled grain/panicle, biological yield (kg/ha), straw yield. However, only biological yield (10488.7kg/ha) and straw yield (6387.47kg/ha) significantly responded to seed rate.

The interaction between N level and seeding rate was significantly different for Panicle length(cm),Filled grain/panicle, Total tiller/m2, effective tiller/m2,Grain yield kg/ha and N concentration,uptake as well as most of N use efficiency parameters. Hence, the highest numbers of total tillers per square meter (420.67), effective tillers per square meter (357.33), number of filled grain per panicle (102),Panicle length(24.20 cm) and highest grain yield (4755.2kgha^{-}1)were recorded at the rate of 96kg N ha^{-1} with 70 kgha^{-1}.This is due to N uptake in grain has positive significant associations with grain yield. Likewise, different N level and seed rate had significantly influenced N concentration, uptake and use efficiency in rice at maturity. The highest N concentration in the straw (0.62%) and grain (1.55%) obtained from 128 kgNha^{-1} with 60 and 70 kg ha^{-1} nitrogen and seed rate respectively. Similarly,the highest straw and total N uptake were recorded for straw and total N uptake at 128 kg Nha^{-1} with70 kg ha^{-1} nitrogen and seed rate. However, for grain N uptake recorded at rate 96 kg Nha^{-1}and 70 kg ha^{-1} seed rate. In addition, N use efficiency parameters (agronomic efficiency, physiological efficiency and Apparent recovery efficiency) were significantly affected by the combined N level and seed rate.The application of N fertilizer significantly increase agronomic N use efficiency(ANUE),physiological efficiency (PNUE) and Apparent recovery efficiency (ARE)to certain level with (64kgNha^{-1}),beyond this rate the efficiency of parameters declined.

The agronomic N use efficiency (ANUE) ranged from 4.63 to 23.63 grain yield per kg N applied. The higher ANUE due to appropriate dose N fertilizer 64kg Nha^{-1}and 70 kg ha^{-1}seed rate respectively, showed that ability to performed higher grain yield and N use efficiency as compared to others with the applied level of N fertilizer and seeding rate. On the other hand, the highest grain yield (4755.2kg ha^{-1}) was obtained from the treatment combination of 96kgN ha^{-1} (208.7kg urea ha^{-1}) applied with70 kg ha^{-1} seed rate.The increased grain yield with increasing rate of N application might be due to the increased N uptake and the increased yield component. The observed positive and strong relationship between grain yield and N uptake showed the contribution of absorbed N to increased grain yield. In addition, the positive and strong association between grain yield and yield related traits were significant .

The increased grain yield with the increased N uptake at the rate of 96kg N ha^{-1} indicated the conversion of absorbed N to grain formation. Therefore, application of nitrogen and seed rate to optimum level (96kgNha^{-1}and70kgha^{-1}seed) increased yield and yield component of rice as well as NUE of rice. But, the highest net benefit (34101ETB) and the marginal rate of return (999%) obtained from 64kgNha^{-1}and70kg ha^{-1}recommended as the most attractive rates for well to do farmers as well as investors. However, as the experiment was conducted in one season and one location, repeating the experiment over years would draw Sound recommendations.

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7. APPENDICES

Appendix Table 1: Mean square of Phenological parameters of upland rice

Source of variation	Mean square								
	df	50% DH	50%DF	90% DM	PH	PL	TSW	TT	ET
Rep	2	1.27^{ns}	7.02^{ns}	12.69 ^{ns}	18.99^{ns}	2.25^{ns}	9.50^{ns}	158.42^{ns}	77.87^{ns}
SR	2	29.60**	18.42^{ns}	50.42**	36.40^{ns}	5.25^{ns}	1.87^{ns}	7.49^{ns}	7810.06^{ns}
N	4	482.20**	234.02**	370.05**	604.69**	58.31**	181.87**	46316.72**	22470.03**
NXSR	8	3.18^{ns}	1.92^{ns}	11.42^{ns}	4.58^{ns}	5.39*	7.05^{ns}	246.07**	2559.23**
Error	28	1.46	8.14	8.33	15.27	1.90	7.62	59.85	256.03

*Where, NS: Non significant at 5%, *: significant at 5% and **: Significant at 1%, df: degree freedom, SR: seed rate ,50%DF: 50% days to flowering , 50%DH: 50% days to heading, 90%DM: 95% days to maturity, PH: plant height, PL: panicle length, TSW: thousand seed weight, TT: total tillers, ET: effective tillers.*

Appendix Table 2: Mean square of yield and yield component of upland rice

Source of		Mean square					
variation	Df	FG	UFG	GY	BY	STY	HI
Rep	2	32.46^{ns}	17.62**	311994.98**	539233.9^{ns}	177620.6^{ns}	6.46^{ns}
SR	2	13.07 ^{ns}	4.69 ^{ns}	973734.30**	20180215.8**	7506995.0**	39.42 ^{ns}
N	4	1506.97**	47.26**	3277222.18**	85773884.1**	38953285.3**	182.86*
NXSR	8	139.48**	2.60 ^{ns}	203898.76**	519562.7 ^{ns}	468329.5 ^{ns}	3.94 ^{ns}
Error	28	15.16	2.43	51310.92	252745.6	232349.0	11.90

Where, N: Nitrogen NS: Non significant at 5%,: significant at 5% and **: Significant at 1%, df: degree freedom, Rep: replication, SR: Seed rate, FG: filled grain, UFG: unfilled grain, GY: grain yield, BY: biomass yield, STY straw yield, HI: harvest index.*

Appendix Table 3 : Mean square of nitrogen uptake and efficiency of upland rice

Source of Variation	df	Mean square							
		GNC	STNC	GNU	SNU	TNU	ARE	ANUE	PNUE
Rep	2	0.003 ^{ns}	0.013 ^{ns}	26.84 ^{ns}	22.00 ^{ns}	94.72 ^{ns}	185.92^{ns}	6.70 ^{ns}	78.08 ^{ns}
SR	2	0.172*	0.006 ^{ns}	899.38**	100.16*	1599.62**	2641.85**	314.64**	3475.31**
N	4	1.763**	0.226**	3927.18**	3103.59**	12636.03**	8447.08**	443.56**	18528.86**
NXSR	8	0.218**	0.0172*	510.31**	140.56**	926.91**	1033.33**	28.13**	2147.59**
Error	28	0.055	0.006	14.02	24.95896	32.66	79.22	2.487794	251.07

*Where, NS: Non significant at 5%, *: significant at 5% and **: Significant at 1%, df: degree freedom, Rep : replication, SR: seed rate ,GNC Grain nitrogen content: STNC straw nitrogen content, GNU: Grain nitrogen uptake, SNU: Straw nitrogen uptake, TNU: Total nitrogen uptake, ANUE: Agronomic N use efficiency, ARE: Apparent recovery efficiency, PNUE: physiological N use efficiency*

Appendix Table 4 : Climate data from wush wush wether station 2017

	Temperature		Rain fall	
Month	Max (^{0}c)	Min (^{0}c)	Rainfall (mm)	Rain day
July	24.4	14.1	219	24
August	23	13.8	206	22
Sept	23.4	12.9	209	20
Oct	25.8	12.4	133.3	6
Nov	26.6	12.8	112	13
Dec	27.3	14.4	50.2	7
January	27.8	14.9	33.6	9
February	30.02	12.89	20.3	5
March	27.03	13.13	124	11
April	25.97	13.4	118	16
May	25.97	13.77	172	16
Jun	23.65	13.22	156	18
Total	307.94	157.71	1553.4	167
Yearly average	28.66	16.14