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Effect of row spacing and nitrogen fertilizer levels on yield and yield components of rice varieties

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ABSTRACT

Rice (Oryza species) is a unique annual cereal food crop growing under flooded condition up to 3000 m.a.s.l and pH 4.5-8.5. Production of rice depends on several factors: climate and crop management. Varieties had significant influence on grain yield, Protein content, number of spike and 1000 grain weight. Total dry matter and crop growth rate observed due to interaction of N rate and varieties. Low tillering varieties particularly short duration ones gave low number of panicles m^{-2} while high tillering cultivars caused competition and more shading consequently low yield. The optimum plant spacing of rice must be identified to obtain high yield, through different utilization of below and above ground resources. Nitrogen availability involved directly or indirectly in the enlargement and division of new cells, and production of tissues which is responsible for increase in growth characteristics particularly tiller numbers, finally determining the number of panicles and spikelet's. N fertilization of rice is affected by varieties, soil type and climatic fluctuations between years, mainly environmental temperature. The interaction effect of varieties, N rate and row spacing significantly determine 1000 grain weight, straw yield and grain yield of rice.

***Keywords*:** Oryza species, Optimum spacing. Nitrogen rate, Varieties

1. INTRODUCTION

Rice (*Oryza* species) is an annual cereal crop belonging to the family of Poaceae. It is one of the most important food crop and a major food grain for more than a third of the world

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population (Zhao *et al*., 2011) in East and South Asia, the Middle East and Latin America from the equator to latitudes of 53º N (in China) and 40º S and elevations (in tropical regions) as high as 3000 meters above sea level (m.a.s.l) (FAO, 2013). It is a short day summer crop grows well in humid tropical regions with high temperature, plenty of rainfall and sunshine in heavy clay or clay loam soils. It is tolerant to a range of soils with pH from 4.5 to 8.5 and can be grown successfully on saline or sodic soils (Anonymous, 2002).

Africa has becoming a big contributor in international rice markets; accounting for 32% global imports. The coalition (CARD) brought together research agencies and regional/ international financial institutions and aimed at doubling rice production in Sub-Saharan Africa from 14 to 28 million tons in 2020. Rice yield in Africa is generally low about 1 t ha^{-1} in uplands, 1 to 2 t ha^{-1} in rain fed lowlands and 3 to 4 t ha^{-1} in the irrigated zones and a range of factor explains this low productivity (African Rice, 2010), but new rice cultivars have a potential yield of greater than 10 t ha^{-1} (Dustin and Sterling, 2005).

In Ethiopia, rice production was started three decades ago and the country is proved to have reasonable potential to grow different rice types in rain-fed lowland, upland, and irrigated ecosystems. The Ethiopian government recognized that rice can significantly contribute to improving food security and poverty reduction (EUCORD, 2012). The estimated potential of Ethiopia for up land rice production is 30 million hectare (MoA, 2010), from this 3.7 million hectare of land are suitable for irrigation (Dawit, 2015).

In 2010 rice were projected to increase from 498,332 tons in 2009 to about 4 million tons in 2019 (NRRDSE, 2010). The area allocated for rice increased from about 156 thousand ha in 2009 to about 774 thousand ha in 2019 (Taddesse, 2011). In 2015/16 cropping season, rice was produced on 45454.18 of land in the country with total production of 1268,064.47 tons respectively (CSA, 2016).

Rice uses as food crop, income source and animal feed in Ethiopia (Teshome and Dawit, 2011). It is used in preparation of local food and beverages (*injera, dabbo*, *genffo, kinche, shorba*, *tella* and *katikalla*) either alone or mixed with other crops (teff, millet, wheat, barley, sorghum and maize). It is an alternative crop available to farmers for efficient utilization of their resources such as land and water under swampy and waterlogged environments. The straw is also used as a source of fuel, feed for animals and thatch making (MoARD, 2010).

Production of rice depends on several factors: climate, physical conditions of the soil, agronomic and management practices, and water management (Jing *et al*., 2008). Improvement of thus different especially nutrient retention practice in the soil, use of optimum rate of nitrogen fertilizer and other nutrients; proper seed rate, effective row and plant spacing, high yielding varieties and/or hybrid varieties are considered to be the major determinants of yield of rice.

Different row spacing affected significantly the number of fertile tillers and total tillers per square meter. Wider row spacing reduces the crop's competitive ability with weeds because it increases the space available for the weeds and decreases the competitive ability of the crop (Martin *et al*., 2010). Some of the commonly used row spacing in different parts of the Africa (Nigeria, Senegal and Tanzania) is 25 to 30 cm (WARDA, 2008). It is, therefore, necessary to determine the optimum plant population per unit area and spacing to obtaining high yield (Rasool *et al*., 2013, Sultana *et al*., 2012).

Fertilizer is an expensive and precious input. The developing countries like Ethiopia are more sensitive to shortage of major fertilizer nutrients especially nitrogen and phosphorus, because the fertilizer input in these countries is less and expensive than its demand. Even when the fertilizer supply is satisfactory, the importance of increasing its use efficiency cannot be underestimated. Determination of an appropriate dosage of application will be both economical and appropriate to enhance productivity and consequent profit of the grower.

Nitrogen is the most essential element that is applied most frequently and with high amount in rice production. High-yielding rice cultivars needs large amount of nitrogen to achieve acceptable grain yields. The reasons in rice production are that crop rotations involving rice do not permit accumulation of soil nitrogen; there are many chemical, biochemical and microbial transformations of nitrogen in flooded soils, and the degree that the nitrogen loss mechanisms operate in flooded soil in rice production (Norman *et al.*, 2003). But application of nitrogen fertilizer either in excess or less than optimum rate affects both yield and quality of rice to remarkable extent (Shukla *et al*., 2015).

At present the recommended N rate ha^{-1} and row spacing for rice in Ethiopia in is 64 kg (46 kg N from urea and 18 kg N from DAP/NPS fertilizer) that are blanket recommended, and 20 cm respectively. Different varieties and crop management require different row spacing and N rates. Improving these agronomic practices is believed to increase production of rice in the area. Therefore, the objectives of this Review were:- to kwon the effect of inter row spacing and nitrogen fertilizer level on grain yield and yield component of upland rice varieties' and to review the interaction effect of inter row spacing and nitrogen fertilizer on yield and yield component of rice varieties.

2. RICE BOTANY AND ECOSYSTEM

The tribe *Oryza* is an isolated group in the family *Poaceae* and is characterized by an aquatic mode of life. From species of *Oryza* only two species, namely Asian rice (*Oryza sativa* L.) and the African rice, (*Oryza glaberrima* Steud*)*, are cultivated and come under the section "*sativa*" (DHAOGTR, 2005). The Asian rice is grown all over the world while African rice has originated and been cultivated in West Africa for about more than 3500 years (Martin *et al*., 2006). Rice is normally a self-pollinated crop but up to 3% natural out crossing may occur depending on the cultivar and the environment, (Poehlman and Sleper, 1995).

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)* and the Asian rice (*O. sativa*) hold up to 400 grains per panicle compared to 75 to 100 grains of its African parents. It 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 and non-shattering grain (Aredo *et al*., 2008).

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; 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. Rice can also be grown under upland conditions without flooding (IRRI, 1993).

Rice is a hygrophyte and often cultivated in the lowlands as a semi-aquatic crop inundated with variable depths of water for a period. Lowland rice cultivation is mainly categorized into flood-prone and rain fed lowlands (IRRI, 1993). Flood-prone lowlands include deep-water (to a depth of 1 m) and floating rice (water depth extending from 1- 6 m). There are, 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).

3. RICE PRODUCTION IN ETHIOPIA

Rice in Ethiopia is among the target crop commodities and considered as a “Millennium Crop” that have received due emphasis in promotion of agricultural production (NRRDSE, 2010). The estimated potential of Ethiopia for upland rice production is 30 million hectare, but production area of rice was lower than other cereals (teff, sorghum, maize and wheat (Dawit, 2015).

Rain-fed rice is cultivated in Amhara, Tigray, Oromia, South Nation Nationality and people region, Gambella and Benshangule Gumuze Regions of Ethiopia (MoA, 2010). The production status of rice was increased on production area, yield in tons and producing farmers. Rice is the second among cereals in terms of average national yield (2.79 t ha^{-1}) next to maize (3.387 t ha^{-1}) (CSA, 2016). The average rice yield ranges from 2.5 to 4.0 t ha^{-1} on-farmers field conditions in different agro-ecologies of the country (MoARD, 2011). In 2014/15 and 2015/16 cropping season, rice was produced on 46,823.22 ha and 45454.18 of land in the country with total production of 1,318,218.53 tons and 1268,064.47 tons respectively (CSA, 2016).

Ethiopia is the only region in the world with the lowest yield in rice. Estimated yields for 2015/2016 was 2.79 tons ha^{-1} (CSA, 2016) compared to 5.80 tons ha^{-1} in Europe, 4.93 tons ha^{-1} in the Americas and 4.22 tons ha^{-1} in Asia in 2006. Most of the increase in production has come from expansion in the area harvested rather than from increases in yields (Sreepada and Vijayalaxmi, 2013).

Ethiopia has a huge potential in both rain-fed and irrigated areas for rice production, which is, estimated about thirty million ha (MoARD, 2010; CSA, 2012). Minilik *et al*. (2013) showed that respondents identified three types of local rice varieties namely X-Jigna, white rice and red rice, and nine improved varieties namely, Gumara, NERICA-1, NERICA-2, NERICA-3, NERICA-4, Suparica-1, Shebelle, Gode-1 and Hoden for seed source. The local variety X-Jigna is the most dominant local variety mainly in Tigray and Amhara.

Nearly all the Asian type rice varieties 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 NERICA (New Rice for Africa) has been recently introduced and grown in the different parts of the country. The NERICA type possess high yielding potential, early vigor, good grain qualities, non-shattering grains, good response to fertilizer applications, short growth cycle, tolerant to drought, and resistant to pests and disease such as blast and yellow mottle virus, and most suitable in altitude below 1500 m.a.s.l(Mulugeta *et al*., 2011).

3. 1. Effect of Row Spacing on Crop Production

Spacing determines the number of plants per unit area (Yoshida *et al*., 1981). The plant to plant and row to row distance determines the plant population per unit area which has direct effect on yield. Closer spacing hampers intercultural operations, more competition arises among the plants for nutrient, air and light as a result plants become weaker and thinner and consequently, grain yield is reduced (Alen *et al*, 2012), significantly greater germination count thus favors more straw yield (Sultana *et al*., 2012).

On the other hand, wider spacing also allows more competition among crop plants and weeds. As a result plant growth slows down and their grain yields decreases (Martin et al., 2010) due to insufficient utilization of the growth factors, but are better residue clearance, lower soil disturbance and reduced machinery cost. Plant population has either asymptotic or parabolic relationship with yield. In the asymptotic relation, yields increase linearly with increased population over the lower range of population. However, in parabolic relationship the total yield decline at higher population and there is an identifiable optimum value (Harper, 2003). Both the biological and economic yields increase with increasing plant population up to a certain optimum point (Mohaddesi *et al*., 2011) and beyond the optimum spacing and economic yield decreases.

3. 2. Effect of Nitrogen on Crop Production

Nitrogen (N) is one of the most yield-limiting nutrients for crop production in the world. It is also the nutrient element applied in the largest quantity for most annual crops (Huber and Thompson, 2007). The amount of N required by crop depends on the type of small grain, the previous crop in the rotation, the soil type, weather conditions, supply of residual, nitrogen fertilizer management and cultural practices during the growing season. Use of low rates for high-yielding modern crop cultivars, especially by farmers in developing countries, is another cause of N deficiency. However higher nitrogenous fertilizer delays the senescence of leaves and increased succulence of plants therefore; physiological maturity was increased with increment in N level (Jiban, 2013).

Nitrogen Fertilizer where needed for optimum yield usually increases slightly the total water used by the crop. But nitrate leaching losses in some cases, especially serious on sandy soils of low water holding capacity and within irrigation. Especially cereals being a shallow-rooted crop with the domain root zone at 20 cm below the soil surface, can lead to considerable nitrate loss by leaching under irrigated or high rainfall conditions (Olson *et al* 1964). Unnecessary use of nitrogen fertilizer in many farmers for best economic return lead to excess nitrate accumulating in forage or ground-water constitutes a hazard to animal and human welfare. Since fertilizer inputs are expensive, so determining an appropriate amount of fertilizer that increase yield and economy and do not have negative effect on environment.

3. 3. Effect of Varieties on Rice Productivity

Variety is the key component to produce higher yield of rice and any other crop depending upon their differences in genotypic characters, input requirements and response, growth process within the prevailing environmental conditions during the growing season (Alen *et al*, 2012). Varieties had significant influence on feed and grain yield, Protein content, number of spike, 1000 grain weight (Alireza, 2015). Plant height also significantly difference between rice varieties (Garbe *et al*., 2013, Buri *et al*., 2015 and Alen *et al*, 2012). Total tiller number per m^{-2}, no. of effective tillers m^{-2}, spikelet no panicle^{-1}, 1000 grain weight, straw yield and grain yield varied significantly in different cultivar (Ahmed *et al*., 1998). Low tillering varieties particularly short duration ones gave low number of panicles m^{-2}, while high tillering cultivars caused competition and more shading consequently low yield of paddy rice (Richards *et al*., 2005). Growth and development of tillers in rice depend partly on environmental factors, especially radiation, temperature and nutritional conditions. Varietal characteristic is a major significance in the tillering ability of the crop and 1000 grain weight (Garbe *et al*., 2013).

3. 3. 1. Interaction of varieties and Nitrogen rate

Ye Quanbao *et al*. (2007) reported that the response of different rice cultivars to N-application was not the same. Significant genetic differences existed among genotype on effect of yield increase with N application, N use efficiency, N accumulation, and distribution in rice under different soil. Due to their high yield potential, NERICAs needs the use of commercial fertilizers in addition to that provided by compost, alley cropping and residual effects from rotations that may be developed with nitrogen fixing legumes (Tareke and Toshoro, 2005). Given the importance of N fertilization on yield, it is necessary to know the rate for each variety. Response of rice varieties to N is generally recognized, but crop recovery of applied N is only 50% due to the losses in several ways. N application at even lower rates significantly increased grain yield of the rice varieties, which responded similarly to nitrogen application. Average across N rates, NERICA –L-12 and NERICA-L-41 produced higher grain yield than ITA 150, NERICA-L-42 and NERICA-L-56 (Kamara *et al*. 2011).

Luka, *et al*., (2013) reported significant interaction on TDM (total dry matter) and CGR (crop growth rate) was observed due to N rate and varieties. NERICA 4 variety shown increases in TDM when N was applied at 65 kg ha^{-1} and further increase to 130 kg ha^{-1} produced similar results. NERICA 8 variety however produced statistically similar TDM throughout the fertilizer levels. The crop growth rate for NERICA 4 was increased with application 65 kg N ha^{-1} but further increase to 130 kg N ha^{-1} depressed CGR, however for NERICA 8 CGR was similar throughout all the N levels.

Buri *et al*. (2015) also reported that two varieties (Sikamo and Jasmine 85) interacted with 60 kg N ha^{-1} level to 150 kg N ha^{-1} gives significantly taller plants. Effect of both N and variety interaction showed that Sikamo at 120 and 150 kg N ha^{-1} gave significantly higher biomass than Sikamo or Jasmine 85 fertilized at 0 or 30 kg N ha^{-1}. There were also no significant differences in number of effective tillers produced in the variety x N rate interaction. Grain yield was significantly higher for Sikamo and Jasmine 85 fertilized at 90 kg N ha^{-1} than the other entire N x Variety interactions except Marshall at 90 kg N ha^{-1} and both Sikamo and Jasmine fertilized at 120 kg N ha^{-1}.

3. 4. Effect of Row Spacing on Rice Productivity

Un-appropriate plant spacing reduces the yield of rice up to 25-30 per cent (IRRI, 1967). The optimum plant population per unit area is a major yield determining factor in wet-seeded rice. It is also essential to find out the optimum seed rate for the better performance of wet-seeded rice (Anissuzzaman *et al*., 2010).

With wider spacing and less competition for nutrients, moisture and light, more photosynthate may be produced at the source and in turn translocated to the sink, thus resulting in higher yield (Garbe *et al*., 2013). Spacing's of 15, 20 and 25cm had significantly higher number of seeds per spike than the broadcast method, possibly because at wider intra row spacing, plants need not compete for light, nutrients and space for growth and development. The lower number of seeds per spike obtained at closer spacing might be due to intense competition for light, nutrients and space.

Optimum plant spacing ensures plants to grow properly both in their above and underground parts through different utilization of below and above ground resources such as solar radiation and nutrients (Mohaddesi *et al*., 2011). In densely populated rice field the inter and intra specific competitions between the plants is high which sometimes results in gradual shading and lodging, and thus favor increased production of straw instead of grain. Closer spacing hampers intercultural operations and as such more competition arises among the plants for nutrients, air, and light. As a result, plants become weaker, thinner and consequently reduces yield.

Ali *et al.* (2011) indicated, at high LAI, the crop tends to bend or lodge, which decreases the CGR. Agronomically there is an optimum growth size for maximum yield. The relative growth rate (RGR) of a plant is a measure of its growth efficiency, i.e. the rate at which a given amount of existing biomass can produce new biomass per unit time. They showed that the ideal spacing of 20×20 cm^2 was determined with an efficient N dosage level of 200 kg N ha^{-1} for Number 843 rice line.

A thick population crop may have limitations in the maximum availability of growth factors. It is, therefore, necessary to determine the optimum density of plant population per unit area for obtaining maximum yields. Increased plant spacing considerably resulted in vigorous plant growth and caused a significant increase in number of panicle hill^{-1}, grain yield hill^{-1}, filled grain panicle^{-1} and 1000 grain weight (Baloch *et al*., 2002).

Singh *et al*. (1983) studied the effect of row spacing in combination with nutrient supply on grain yield of semi dwarf upland rice variety Narendra-1 (IET 2232), the crop was grown by direct seeding in rows at three spacing of 15, 20 and 25cm. The grain yield was more with 20 cm spacing as compared to other spacing. The more vigorous plants, with particularly higher tillering ability produced more photosynthate than the less vigorous plants at the closer spacing (Ogbodi *et al*., 2010). In closer spacing the yield was reduced, despite increasing of number of plants per unit area because of decreasing of panicle. On the other hand, because of more closing and shadows, due to changing of light intensity and quality, the competition for light increased and these elements affected on crop ideal growth. Ali *et al*., (2011) showed that plant spacing of (20×20) cm^2 gave sufficient number of plant and high relative contribution of main stem and primary tillers in the grain yield than the other plant spacing.

3. 5. Effect of Nitrogen on Rice Productivity

Intensive agriculture, involving exhaustive high yielding varieties of rice and other crops, has led to heavy removal of nutrients from the soil. Imbalanced use of chemical fertilizers has resulted in deterioration of soil health (Talpur *et al.*, 2013). Among various nutrients, nitrogen is integral part of structural and functional protein, chlorophyll and nucleic acid. It plays a vital role in crop development.

Nitrogen is the main nutrient associated with yield (Jing *et al*., 2008), it provides sink during the late panicle formation stage. The number of panicle per hill increased with increased level of nitrogen (Haque and Haque, 2016). The reduction of tiller number per plant at later growth stage might be due to tiller mortality under intra plant competition for growth resources. Increase of nitrogen levels involved directly or indirectly in the enlargement and division of new cells and production of tissues which in turn were responsible for increase in growth characteristics particularly increase in plant height and tiller numbers (Kandil *et al*., 2010) finally determining the number of panicles and spikelet's during the early panicle formation stage.

There are many factors responsible for low yield of rice such as plant density, sowing time, judicious use of nitrogenous fertilizer, time of application etc. Nitrogen application increased rice grain yield and yield components (Kamara *et al*, 2011). The grain yield and yield components of the rice crop responded more to N than to P fertilization. But the combined application of N and P fertilizers increases in yield and yield components (Heluf and Mulugeta, 2006).

Rajarathinam and Balasabramaniyan (1999) indicated that yield parameters (panicles m^{-2}, panicle weight and length, grains panicle^{-1}, filled grains panicle^{-1}, 1000-grain weight), grain yield and harvest index were highest with the 200 kg N ha^{-1}. Application of the intermediate level of N (60 kg ha^{-1}) was economical and environment-friendly for the cultivation of new rice variety than 80 kg N and 100 kg N ha^{-1}(Haque and Haque, 2016). Estimation of optimum fertilizer rate is important because of growing economic and environmental concerns. Naser *et al*. (2011) showed the highest grain yield, grain per panicle, 1000 grain weight, straw yield, HI and number of bearer tillers (m^{-2}) was increased with increasing N level up to 120 kg ha^{-1}.

Application of N fertilizer properly increased 70-80% of rice yield (IFC, 1982). The highest number of filled grains per panicle was recorded at 60 kg N ha^{-1}, but number of tillers hill^{-1} and dry mater accumulation maximum at100 kg N ha^{-1} and lowest was on the control treatment. Ye Quanbao *et al*. (2007), indicates rational N application is important factor affecting rice yield and quality.

Total number of tillers per m^{-2} significantly increased by 103% over the control for 150 kg N ha^{-1} (Buri *et al*., 2015). Total biomass increased with increasing levels of N up to 150 kg N ha^{-1}, but N greater than 90 kg ha^{-1}, more tillers tended to be un-productive resulting in lower paddy yield. Grain yield also increased with increasing levels of N from 1.7 t ha^{-1} (0 kg N ha^{-1}) to a maximum of 9.4 t ha^{-1} (90 kg N ha^{-1}) and thereafter declined, indicating that higher levels of N suppressed yield. This showed, after 90 kg N ha^{-1}, further N addition seemed to contribute more to vegetative growth (greater straw production) at the expense of reproductive growth (grain production).

3. 5. 1. Interaction Effect of Row Spacing and Nitrogen Fertilizer Levels on Rice Productivity

When the plant density exceeds an optimum level, competition among plants for light above ground or for nutrients below the ground become severe, consequently the plant growth slows down and the grain yield decreases. If mutual shedding/over lapping is the limiting factor for nitrogen response, nitrogen response can be improved by giving individual plants more light by increasing the space between them (Ali *et al.,* 2011).

Grain yield of rice increases with the increase in number of hills per unit area. Study on different seeding rate (9 kg ha$^{\mathbf{-1}}$, 12 kg ha^{-1}, 15 kg ha^{-1}, 18 kg ha$^{\mathbf{-1}}$ and 21 kg ha$^{\mathbf{-1}}$) with three N levels (100 kg ha$^{\mathbf{-1}}$, 120 kg ha^{-1} and 140 kg ha$^{\mathbf{-1}}$) showed that the highest total number of effective tillers hill^{-1} and highest grain yield were obtained in the treatment combination of 15 kg seed ha^{-1} and of 140 kg N ha$^{\mathbf{-1}}$ of direct seeded hybrid boro rice (Anissuzzaman *et al*. 2010). The optimum amount of nitrogen and planting density differ with varieties or genotypes. According to Chang and Su (1977) study in two rice cultivars, number of tiller per hill at 50 days after transplanting increase with increasing rate of applied N and decreases with decreasing in spacing while plant height increased as rate of N increased and spacing decreased.

Ahmed *et al*. (1998) showed length and weight of panicles, number of panicles per hill and grains per panicle increased with increased rate of N and increased spacing. They stated that interaction effect of varieties and nitrogen rate was significantly affected 1000 grain weight, straw yield and grain yield. The interaction effect of Plant spacing, rice varieties, and depth of planting had significant difference in weight of panicles, grains per panicle, healthy grains per panicle, less no. of non-effective grains per panicle and yield (Archana, *et al*., 2016). The respective highest rate of N, 69 kg N ha^{-1} and of sowing density, 120 kg seed ha^{-1}, produced significantly higher rice straw yield than their corresponding lowest levels, i.e., no N (control) and 60 kg seed ha^{-1}(Sewenet, 2005).

4. CONCLUSIONS

Rice (*Oryza* species) is an important annual food crop in the world. It is a short day summer crop grows well in humid tropical regions. Rice production in Africa is generally low, but new rice cultivars have a potential yield of greater than 10 t ha^{-1}. Ethiopia have reasonable potential to grow different rice types in rain-fed lowland, upland, and irrigated ecosystems, but productivity was low (27.9 t ha^{-1}) compare to yield potential of rice. Production of rice depends on climate, management practices, physical conditions of the soil, soil fertility, water management, and high yielding varieties. Low tillering varieties particularly short duration ones gave low number of panicles m^{-2}, while high tillering cultivars caused competition and more shading consequently low yield.

Optimum plant spacing ensures plants to grow properly both in their above and underground parts through different utilization of below and above ground resources to increase 25-30 per cent yield. Nitrogen is integral part of structural and functional protein, chlorophyll and nucleic acid, and main nutrient associated with yield. It was involved directly or indirectly in the enlargement and division of new cells, and production of tissues which in turn were responsible for increase in yield component and yield during the early panicle formation stage. Excessive as well as low application of nitrogen fertilizer causes lower number of filled grains and higher number of un-filled grains per panicle of rice.

From literature, rice response to N fertilization is affected by varieties, soil type and climatic fluctuations between and row spacing. Total dry matter and crop growth rate was observed due to N rate, varieties and row spacing interaction. Hence in developing countries like Ethiopia, proper management of optimum plant spacing and crop nutrition especially nitrogen depend on varieties are immense importance to increase productivity and production of rice.

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