E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2018; 1(2): 60-66
Received: 20-06-2018
Accepted: 22-08-2018

Tojora Mengistu
Plant Science Department, College of Agriculture and Natural Resources, Mizan Tepi University, Mizan Teferi, Ethiopia

Corresponding Author:
Tojora Mengistu
Plant Science Department, College of Agriculture and Natural Resources, Mizan Tepi University, Mizan Teferi, Ethiopia

Role of macro nutrient for rice production: Review articles

Tojora Mengistu

Abstract
Rice (*Oryza sativa* L.) is a major cereal crop in world that is consumed as the staple food especially in India. In Africa Tanzania, Kenya and Burundi are the most producers of rice. Also in Ethiopia the rice crop is used as staple crop in some parts of the country. Especially in south nation nationality and people of Ethiopia it is highly used. But as different literature, the productivity of the rice crop can be affected by the availability or absence of macro nutrients. The objective of this review is to collect different information on the role of macro nutrient on rice production. The most macro nutrient that determine the production of rice crops are: nitrogen, phosphorus, potassium, calcium, magnesium and sulfur. Those nutrients are the most essential that determine the life cycle of rice crop.

Keywords: crop production, macro nutrient, phosphorus, rice

1. Introduction

Rice (*Oryza sativa* L) is a major cereal crop in world. It is widely consumed by majority of human population as a staple food. More than 90% of total rice production in world is produced and consumed in Asia. India and China are the most important countries of Asia in rice production. It constitutes 23% of the global cereal acreage (680 million ha) and 29% to the global cereal production (2064 million tons). Rice plays a vital role in our food as well as nutritional security for millions of livelihood. Thus the slogan "Rice is life" by IRRI during 2004 seems to be the most appropriate (Chandrasekaran *et al.*, 2007) [25]. Rice ranks second to wheat in terms of area harvested but in terms of importance as a food crop, rice provides more calories ha-1than any cereal crop (De Dutta, 1981) [31, 32]. Besides its importance as food, rice provides employment to the largest sector of the rural population in most of the Asia. With the burgeoning increase of population, demand for food is on high. It has been estimated that rice demand in 2025 will be 765 million tons in the world. Rice is essential for food security, poverty alleviation and improved livelihoods. Rice is the staple food of over half of the world population (Anonymous, 2013).

Rice is one of the largest traded commodities in the world with a total quantity touching 16.4 million tons. The south east countries account for about 40 per cent of the rice trade in the world (Mangla, 2004). Rice is the staple food crop of 63 to 65 per cent people of India. The crop at present is grown in 43 million hectares of land with production of 96.7 million tons. Its production has to be raised to 160 million tons by 2030 with a minimum annual growth rate of 2.35 per cent (Mishra *et al.*, 2013).

Rice is by far the most economically important food crop in many developing countries, providing two thirds of calorie intake of more than 3 billion people in Asia, and one third of the calorie intake of nearly 1.5 billion people in Africa and Latin America (FAO, 2004). Worldwide, rice is the second most important cereal crop after wheat. Most of the world's rice is cultivated and consumed in Asia, which constitutes more than half of the global population. Approximately 11% of the world arable land is planted annually to rice (Chakravarthi and Naravaneni, 2006) [22].

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

Rice was introduced and evaluated initially at different areas of Ethiopia such as Gembella, Pawe, and Fogera in the late 1960s. However, attention was not given to rice research prior mid 1990s. Since 1990, seven upland rice varieties including two NERICAs (New Rice for Africa) have been released. The average productivity of these varieties ranges from 2.5 to 4 t/ha on farmers fields (Wolelaw, 2005) [63]. Ethiopia has different rice agro-ecologies that can grow rain fed upland rice, rain fed lowland rice, and irrigated rice with a total potential land mass of 1 million hectare (Sewagegne, 2005). However, this yield is very low as compared to the world production due to different constraints among which soil fertility problem is the first.

Next to wheat most of arable soil of the world is used for rice growing. Suitable growth of this plant is under the acidic soil pH (5.5 to 6.5) condition, where most nutrients can be taken up by the plant especially micronutrients (Qasempour and Khodabandeh, 2004) [52]. Fajeria *et al*. (1999) [8] reported that the best rice yield is obtained in the soil that has pH about 6 and it decreases in higher pH. At that pH (6.0), the absorption of P, Fe, Zn and Mn by rice plant also increased (Malakoti and Nafisi, 1996) [56]. The pH of soil decreases by addition of sulfurous and nitrogen fertilizers (Benbi and Nieder, 2004) [13]. Macronutrients basically perform a counter role in various metabolic processes of plants and human beings, and are therefore required in large quantities for their survival. On the basis of their functions, macronutrients have been classified into two groups: primary macronutrients, i.e., N, P, and K, and secondary macronutrients, i.e., Ca, Mg, and S (Morgan and Connolly 2013) [42]. Therefore the objective of this assignment is to review on the role of macronutrients such as N, P, K and etc on rice production.

2. Macronutrients

Macronutrients basically perform a counter role in various metabolic processes of plants and human beings, and are therefore required in large quantities for their survival. On the basis of their functions, macronutrients have been classified into two groups: primary macronutrients, i.e., N, P, and K, and secondary macronutrients, i.e., Ca, Mg, and S (Rowley *et al*. 2012; Morgan and Connolly 2013) [42].

These primary and secondary macronutrients play significant role during the entire plant life by performing various beneficial activities in plant metabolism as well as protecting plants from various abiotic and biotic stresses including the stresses of heavy metals, drought, heat, UV radiations, and from diseases and insect pest attacks (Morgan and Connolly 2013) [42]. These macronutrients also help to increase the yield, growth, and quality of various crops (Morgan and Connolly 2013) [42]. Moreover, in recent years, plant physiologists, biotechnologists, and eco-physiologists have been working to investigate various other blind features of these minerals and discuss their future prospective because of nutrients involvement at each step of plant life. Every macronutrient has its own unique character, and is therefore involved in different metabolic processes of plant life.

2.1. Role of Nitrogen on rice production

Nitrogen is required for plants in the greatest amount, which comprises about 1.5–2.0 % of plant dry matter, besides approximately 16 % of total plant protein (Alvarez *et al*. 2012) [5]. Nitrogen plays a key role in rice production as it is required in huge amount. It is the essential component of cell molecules including chlorophyll, nucleic acids, amino acids, ATP and a number of plant hormones. It is an important regulator involved in many biochemical processes such as protein synthesis, carbon metabolism and amino acid metabolism (Cai *et al.*, 2012) [18]. Application of nitrogen fertilizer either in excess or less than the optimum level both affects yield and quality of rice to the significant extent (Manzoor *et al*., 2006) ; that's why appropriate fertilizer input is required not only for getting high grain yield but also for attaining maximum profit (Khuang *et al*., 2008) [46]. The best dose of mineral fertilizer is that which gives maximum economic return at minimum cost (Ananthi *et al*., 2010) [7]. Proper management of crop nutrition is of huge importance as judicious and proper use of fertilizers makes remarkable improvement in the yield and quality of rice (Alam *et al.*, 2009) [3].

Ehsanullah *et al.* (2012) [6] reported that plant height had increased gradually with the increase in nitrogen fertilization to Basmati rice. Maximum plant height (107.60 cm) was recorded when nitrogen was applied at 125 kg ha 1, while minimum plant height was (100.6 cm) obtained when 75 kg N ha 1was applied. Awan *et al*. (2011) [12] found the significant effect of nitrogen on plant height of rice variety KSK-133, maximum plant height (80.00 cm) was observed when N was applied at 156 kg ha 1while minimum of (69.43 cm) was recorded in case of 110 kg N ha 1. Kaushal *et al*. (2010) [39] recorded taller plants (115.6 cm) when nitrogen was applied at 150 kg ha 1while minimum (104.1 cm) was obtained in case of 90 kg N ha 1

Yoseftabar (2013) [64] reported maximum tillers (27.6) when nitrogen fertilizer treatment was 150 kg ha 1 and minimum (22.8) was obtained by applying nitrogen at the rate 50 kg ha 1. Abou- Khalifa (2012) [2] evaluated some rice varieties under different nitrogen levels and found maximum tillers m 2 (704) when nitrogen was applied at the rate 220 kg ha 1while minimum (574) was recorded at control having no nitrogen application. Awan *et al*. (2011) [12] evaluated medium grain rice variety KSK-133 under different levels of nitrogen and row spacing. They reported maximum tillering m 2 (601) when nitrogen was applied at maximum rate i.e. 156 kg ha 1, while minimum number of tillers (527) were recorded when nitrogen was applied at low rate of 110 kg ha 1. Rice CV "Giza 177" was evaluated using three hill spacing, five nitrogen levels (0, 48, 96, 144 and 192 kg ha 1) and three harvest dates during the year 2000 and 2001. It was found that maximum tillers m 2 (439.9 and 477.0) was produced by applying nitrogen at 192 kg ha 1 and minimum number of tillers (373.6 and 360.9) was obtained in control treatment where no nitrogen was applied to soil (Kandil *et al*., 2010) [38].

According to Yoseftabar (2013) [64] productive tillers increased significantly by increasing level of nitrogen. Maximum numbers of productive tillers (21.81) were obtained when nitrogen was applied at maximum rate 150 kg ha 1while minimum numbers of productive tillers (17.15) were given by minimum level of nitrogen 50 kg ha 1. Hasanuzzaman *et al.* (2012) [18] observed more productive tillers hill 1 (11.42) when 200 kg nitrogen was used per hectare while minimum value (10.12) was given by control having no nitrogen application. Ehsanullah *et al.* (2012) [6] recorded more productive tillers hill 1 (18.00) when nitrogen was applied at 125 kg ha 1, while minimum (11.67) was observed when nitrogen was applied at low rate of 75 kg ha 1. Kaushal *et al*. (2010) [39] counted more productive tillers m 2 (48.3) when maximum level of nitrogen (150 kg ha 1) was applied.

Yoseftabar (2013) [64] noticed that panicle length increased with an increase in nitrogen fertilization, maximum panicle length (28.64 cm) was obtained by applying 300 kg N ha 1while minimum was counted when nitrogen was applied at 100 kg ha 1. Abou- Khalifa (2012) [2] checked some rice varieties under different levels of nitrogen and found the significant effect of nitrogen on panicle length. Nitrogen fertilization at higher rate gave rise to increase panicle length (20.81 cm) while control having no nitrogen application gained minimum panicle length (18.23 cm).Yoseftabar (2013) [64] reported that number of grains panicle 1increased significantly with increase in nitrogen rate and maximum number of grains panicle 1 (209.85) were recorded when nitrogen was applied at 300 kg ha 1while minimum (190.31) was observed at 100 kg N ha 1. In another field study Yoseftabar (2013) [64] found more grains panicle 1 (96.51) when nitrogen was applied at 150 kg ha 1while minimum (94.94) was obtained at 50 kg N ha 1. Abou-Khalifa (2012) [2] counted higher number of grains panicle 1 (117) when nitrogen was applied at maximum rate while minimum (105) was recorded at control with no nitrogen application during the year 2011.

Nitrogen applied at higher rate of 156 kg ha 1produced significantly number of grains panicle 1 (132.97) while minimum (119.43) was recorded in case of 110 kg N ha 1 (Awan *et al.,* 2011) [12].

Hasanuzzaman *et al*. (2012) [18] reported the significant effect of nitrogen rates on number of filled grains panicle 1. They reported maximum value (154.67) of filled grains when nitrogen was applied as urea super granules at 75 kg ha 1which was statistically at par with 80, 120 and 160 kg N ha 1and minimum value (126.16) was given by control with no nitrogen application. Whereas Ehsanullah *et al*. (2012) [6] reported that different nitrogen levels had no significant effect on number of kernels panicle 1. Metwally *et al*. (2011) [33] checked the response of hybrid rice to different levels of nitrogen and found that number of filled grains panicle 1increased significantly with increase in nitrogen level up to certain limit and then starts declining with further increase.

Yoseftabar (2013) [64] tested hybrid rice using three levels of nitrogen and reported maximum paddy yield (8611.0 kg ha 1) by applying maximum level of nitrogen (300 kg ha 1) while minimum grain yield (6989.8 kg ha 1) was obtained at low level of nitrogen (100 kg ha 1). Whereas, Sharma *et al*. (2012) recorded maximum grain yield (5015 kg ha 1) when nitrogen was applied at 90 kg ha 1to basmati cultivars while yield decreased with further increase in nitrogen to 120 kg ha 1. Abou-Khalifa (2012) [2] evaluated rice varieties to different levels of nitrogen and found higher grain yield (10.64 t ha 1) when nitrogen was applied at maximum level (220 kg ha 1) whereas minimum (7.11 t ha 1) was recorded in case of no nitrogen application. Awan *et al*. (2011) [12] also reported maximum grain yield (5461.03 kg ha 1) of rice variety, KSK-133 when nitrogen was applied at higher rate (156 kg ha 1) while minimum (4354.60 kg ha 1) was recorded from low level of nitrogen fertilizer (110 kg ha 1).

2.2 Role of Phosphorus on rice production

Phosphorus is abundantly present in the form of phosphate in cell membranes of the plant, where it plays vital roles in being the constituent of DNA, RNA, and ATP (Brown and Weselby 2010) [16]. Thus, it is regarded as an essential component for growth and development of plants; however, its availability in soil is often low, and therefore its high amount in the form of organic phosphate is exogenously used to attain high crop yields (Huang *et al*. 2011) [33]. Among crops, barley (Hordeum vulgare) and wheat (Triticum aestivum) plants use around 46 % of P in the form of fertilizers (Hackenberg *et al*. 2013) [16]. But wide ranging fertilization in the crop fields with extensive Pleads to fast exhaustion of nonrenewable P wealth, and therefore contributes to environmental pollution; however, its deficiency in soil causes significant reduction in crop yields (Gahoonia and Nielsen 2004; Huang *et al*. 2011) [14, 33]. The deficiency in available P is reported to be related to low soil organic matter, low soil pH, inherent low P contents in the parent materials of the soils and presence of P-fixing compounds in soils and inadequate application of P fertilizers (Owusu-Bennouah *et al*., 1991) [44]. Kavanová *et al*. (2006) [43] reported that lack of phosphorus content causes a decline in cell division and cell elongation in the leaves of various grasses. It has been well reported that P is a necessary component of photosynthetic processes which are systematically implicated in creation of sugars, oils, and starches and which further helps in the conversion of solar energy into chemical energy, proper plant maturation, and withstanding stress.s

A ccording to Prosper and Jerome (2017) [47], plant height increased with increasing P rates. The shortest plant heights (23.47 and 28.83 cm) were observed in plots without P (control plots) while the tallest plant heights (58.50 and 66.17 cm) were observed in plots with 60 kg P ha-1. It has been reported that after rice plants have attained the vegetative stage, then the differences in P did not affect the plant height significantly De Datta (1981) [31, 32]. It could be said that P can increase the plant height at initial stage of rice life cycle. A study Morgan (1997) [40] also reported similar effect of phosphorus on plant height. Plants grown without P fertilizer produced the shortest plant irrespective of growth stages. De Datta (1981) [31, 32]. reported stunted plant height due to deficiency of phosphorus. The increase in plant heights had positive effects on dry matter and grain yields.

The rice straw yields increased with increasing rates of P for all the P sources (Prosper and Jerome 2017) [47]. The response of rice plant in term of straw yields to P sources and application rates were statistically significant. Phosphorus application rates from all P sources had a positive effect on rice straw yields and the increase was attributed to the increased soil P as the soils were initially medium in soil P. Mongia *et al*. (1998) [39] reported significant positive effects on straw yields of rice when phosphate was applied and that the highest response of 6.8 tons/ha of rice grain was obtained at 80 kg P ha-

1. The increase in rice straw yields conforms to the trends of increases in plant heights and number of tillers with increasing P application rates.

The grain yields increased with increasing rates of P applications from all sources at both sites (Prosper and Jerome 2017) [47]. Mongia *et al*. (1998) [39] reported significant positive effects on grain yields of rice when phosphate was applied and that the highest response of 6.8 tha-1of rice grain was obtained at 80 kg P ha-1. In addition, the availability of P influenced the uptake of other essential plants nutrients due to role of P in the rice plant roots. Further, the observations from the current study showed that, plant heights, number of tillers per plant and dry matter yields were significantly correlated with grain yields at harvest. This means that the performance of rice plant in terms of grain yield depends on increased yield components attributed to appropriate management of soil fertility and productivity.

2.3 Role of Potassium on rice production

Potassium is an essential nutrient that is absorbed by plants in larger amounts than any other nutrient except N (Roy *et al*., 2006) [54]. Unlike N, P and most other nutrients, K is not incorporated into structures of organic compounds; instead potassium remains in ionic form (K^+) in solution in the cell and acts as an activator of many cellular enzymes (Havlin *et al*.,

2005) [23]. Therefore, it has many functions in plant nutrition and growth that influence both yield and quality of the crop. These include regulation of metabolic processes such as photosynthesis; activation of enzymes that metabolize carbohydrates for synthesis of amino acids and proteins; facilitation of cell division and growth by helping to move starches and sugars between plant parts. It is reported that among the many plant mineral nutrients potassium (K) stands out as a cat ion having the strongest influence on quality attributes that determine fruit marketability, consumer preference, and the concentration of critically important human-health associated phyto-nutrients or bioactive compounds (ascorbic acid and Beta carotene) (Lester *et al*., 2010) [52].

Potassium is a necessary and extremely mobile macronutrient in plants that is abundantly present in young parts of the plants. However, Fernando *et al*. (1992) [12] reported that cytosol contained its highest amount, i.e., 30–50 mMm, while 20 mM was found in vascular region of the cells. Mengel (2007) [58] suggested that K plays a major role as a cationic inorganic element in the plants and is therefore regarded as an essential element to all plant life, and plants cannot survive without its presence. It is linked to many physiological processes which help in improving photosynthesis, enzyme activation, water relations, assimilates, transportation, as well as plant growth and development (Zlatev and Lidon 2012) [63]. Helal and Mengel (1979) [23] revealed that if K+supply is poor in plants, protein synthesis will be inhibited and, therefore, forerunners of proteins like amino acids, amides, and nitrate could be accumulated.

According to A.M. *et al*. (2001) [1] the growth parameters of rice plant were no longer affected by the either source of K fertilization this was because of adequate quantity of K (139 mg kg-1) already in the soil. Moreover, there were no ill effects of Cl even at very higher rate i.e. 500 mg kg-1soil which might be due to the reason that a long period is required to develop Cl toxicity in restricted drainage soil as in this case, because the pots were closed from below and there was no leaching of Cl from these pots. Plant roots do not have a specific transporter for Na uptake. The entry of Na into root cells is mediated by nonselective cation facilitators (Malagoli *et al*., 2008; Munns and Tester, 2008). Eliminating Na uptake and increasing K accumulation in the shoot is an important strategy in plants for salt stress tolerance (Munns and Tester, 2008). Therefore, enhancing the expression of high-affinity HAK transporters is an attractive target for the improvement of K acquisition and plant growth under saline conditions (Nieves-Cordones *et al*., 2010).

2.4. Role of Magnesium on rice production

Magnesium is a very common element which is found in all living beings on earth; among the comparative list of abundance, it is the eighth most abundant element on the earth crust and ninth in the universe Luft (2012) [55]. Magnesium is a central atom of chlorophyll and therefore plays a major role in plant photosynthesis, and thus its deficiency degrade the chlorophyll content and leaves become yellowish in color, which is known as chlorosis; however, an adequate supply of Mg makes the plant healthy (Hermans *et al*., 2010). Low or excess levels of Mg contents in plants may serve diverse impact on photosynthesis. As it is a movable element in plants, chlorophyll of the plants is first decreased in old leaves and the remaining amount of Mg in old leaves is transferred to younger leaves (Hermans *et al*. 2010). Studies suggested that Mg is an active constituent of electron transportation chain; therefore, during the entire process of electron transport chain of the chloroplast, Mg has a significant responsibility. Furthermore, due to the presence of appropriate level of Mg content, the action of ant oxidative enzymes and the content of antioxidant molecules were reported to be increased in pepper, maize, bean, mulberry, and Mentha pulegium (Waraich *et al*. 2012) [59].

It is the secondary nutrient element that is important as a primary constituent of chlorophyll and as a structural component of ribosome's, it helps in their configuration for protein synthesis (Halvin *et al*., 2005) [23]. It is also required for maximum activity of almost all phosphorylating enzymes in carbohydrate metabolism. Adequate levels of Mg in USA reported increased quality and profits of potato due to improved potato specific gravity Hoyun, (2000). Increased specific gravity of potatoes can be attributed to increased carbohydrate synthesis and deposition from the leaves. Usually, the first things to be noticed due to influence of Mg are chlorophyll level, photosynthesis (photosynthetic CO2fixation), and protein synthesis, however, recently, distribution of carbohydrates among shoot and root organs have been reported as well Chakmack, (2010). These in turn affect quality of plant product depending on which part is used for food by humans or animals. A four-fold increase of sucrose in leaves of Mg-deficient sugar beets compared to the Mg-adequate sugar beet plants was reported and this affected quality of Mg-deficient sugar beets (Hermels *et al*., 2010). This was attributed to inhibition of sucrose/sugar distribution from leaves to root organs in the Mg-deficient plants.

A study carried out by Ding *et al*. (2008) clearly revealed that low level of Mg in rice plants was negatively associated with the concentration of Malondialdehyde (MDA) and three anti oxidative enzymes; however, exogenous supply of Mg and K in rice plants showed significant interactive effects in shoot biomass, yield, chlorophyll content, photosynthetic rate, and the activities of SOD, catalase (CAT), Peroxidase (POD), and MDA contents (Ding *et al*. 2008). Chen *et al*. (2012) reported that Mg alleviates stress in rice, and this behavior is closely associated with Mg transporter. Further, Chen and Ma (2013) stated that Mg alleviates Al toxicity through functioning of Mg transporters, which are accountable for its adequate translocation, distribution, and

uptake in rice plants.

2.5. Role of Calcium on rice production

Among the list of all available elements, calcium is found to be the fifth most plentiful element on the earth crust, and is also regarded as the fifth most ample liquefied ion in ocean (Krebs 2006). It is one of the most essential elements for all living organisms and is required particularly in the form of calcium ions (Ca2+) that helps as well as participate in many cellular processes (White and Broadley 2003) [59]. It is important to every plant for their growth and development and is involved in activating the enzymes, inducing water movement and salt balance in plant cells, and also activating K to control the process of opening and closing of stomata (Hepler 2005) [27]. It is also required for cell growth, division, elongation, and various essential biological functions (Hirschi 2004). Calcium boosts the nutrient uptake, improves the plant tissue's resistance, makes cell wall stronger, and contributes to normal root system development (Berridge *et al*. 2000) [13].

Hepler (2005) [27] noticed that Ca is an essential regulator of plant growth and development and that deficiency in plants causes yellow coloration and black spots on leaves. Further, when deposited in plant tissues, it is immobile. For this, cells have developed several mechanisms for strongly regulating calcium ion (Ca2+) fluxes as well as different Ca pools, and thus it is keenly transported from the cytosol into the mitochondria, endoplasmic reticulum, cell walls, plastids, and vacuoles (Volk *et al*. 2004) [57].

Application of calcium silicate at 2t ha-1significantly increased grain and straw yield of wetland rice when applied along with 100 kg N ha-1 as compared to RDF alone and control. Increase in straw yield was mainly attributed to higher tiller numbers, biomass observed in the treatment with calcium silicate at 2t ha-1. The enhanced straw yield with calcium silicate at higher N levels may be attributed to leaf erectness which facilitated better penetration of sunlight leading to higher photosynthetic activity of plant and higher production of carbohydrates (Korndorfer *et al.*, 2001).

Paddy yield improved because of Ca application to salt affected soil. Although application of Ca had a consistent and positive effect on mean paddy yield under salt affected soil conditions, the results were significant only at 100 and 200 kg Ca ha-1. When cultivars and soils were separately considered, KS- 282 produced significantly higher paddy yield than BG-402-4 followed by IR-28 in both soils and overall mean paddy yield was significantly higher in saline than saline sodic soil. Among Ca levels, 200 kg Ca ha-1resulted in the harvest of the highest paddy yield compared with all the other levels of Ca. An adequate supply of Ca along with other nutrients to plants, therefore, may mitigate the deleterious effects of salinity (Aslam *et al*., 2000) [10]. Elevated levels of external Ca can increase both growth and Na exclusion of plant root exposed to NaCl stress (LaHaye & Epstein, 1971) [49]. Calcium application in the present study improved the growth parameters both in solution and soil cultures.

2.6. Role of sulfur on rice production

Sulfur (S) is the ninth richest element on the earth's crust, which is naturally found in the form of pure sulfide and sulfate minerals (Khan and Mazid 2011) [45]. It is known as the most beneficial element for all living organisms and performs various dynamic roles for growth, development, and survival of plant life. Therefore, for maximum production, it is regarded as an essential plant nutrient necessary for all crop plants. Generally, plants take sulfur in the form of sulfate (SO42) which is very mobile in soil and recognized as the fourth most necessary element for the plants after N, P, and K (Jamal *et al*. 2010) [34]. Increased rice grain quality (N content) by S containing nitrogenous fertilizers, supernet (1.73%

N) and ammonium sulphate nitrate (1.66% N) as compared to urea that produced 1.45% N was reported in India

(Chaturvedi, 2005) [26]. This could be attributed to the role of S in protein synthesis in which is used as an essential component of amino acids and also the balanced fertilization that lead to the general high performance of the crop including synthesis of all N containing compounds such as proteins, chlorophyll and nucleic acids. There is some evidence that fatty acids cause a disease in rice and the Effects of butyric acid on rice have been demonstrated. Methanogenic and sulfate reducing bacteria may therefore play a vital role in detoxification processes in Paddy soils by their mutualistic oxidation of fatty acids.

Sulphur is an integral part of amino acids. Helps develop enzymes and vitamins. It promotes nodule formation on legumes, aids in seed production and necessary in chlorophyll formation. Major role of S has been differently recognized, i.e., it plays a crucial role in the synthesis of chlorophyll, proteins, seeds oil content, as well as amino acids methionine and cysteine (Jamal *et al*., 2010) [34]. These amino acids are involved in metabolic activities of vitamins, biotins, thiamine and coenzyme A. Crop-plants fulfill there all S requirements through soil in the form of sulfate (SO4) which convert into organic matter after assimilation. Crops grown in industrial areas can absorb sulfur present in the air in the form of sulfur dioxide (SO2). In our soils, sulfur is present in large amounts in the form of sulfate albeit in the mountainous areas; it dissolves and flows down with the water. In rice-crop, due to standing of water, it converts into sulfur oxide and causes its deficiency. Continuous use of sulfur free fertilizers like urea and DAP causes its deficiency in crop-plants. In nitrogen deficient plants, lower and upper all leaves shows symptoms whereas in S deficient plants it appear on the new leaves only.

3. Summary

Rice is by far the most economically important food crop in many developing countries, providing two thirds of calorie intake of more than 3 billion people in Asia, and one third of the calorie intake of nearly 1.5 billion people in Africa and Latin America. I n Ethiopia rice is the most essential crop that growth in some parts of Ethiopia. But the productivity of rice may be influenced by excess or deficiency of nutrients. Macro nutrients are the major nutrient that is essential for the final productivity of rice. Macro nutrient can be classified into two major parts. Those are primary and secondary macro nutrients. primary and secondary macronutrients play significant role during the entire plant life by performing various beneficial activities in plant metabolism as well as protecting plants from various abiotic and biotic stresses including the stresses of heavy metals, drought, heat, UV radiations, and from diseases and insect pest attacks.

Nitrogen is required for plants in the greatest amount, which comprises about 1.5–2.0 % of plant dry matter, besides approximately 16 % of total plant protein. Nitrogen plays a key role in rice production as it is required in huge amount. It is the essential component of cell molecules including chlorophyll, nucleic acids, amino acids, ATP and a number of plant hormones. Plant height had increased gradually with the increase in nitrogen fertilization to Basmati rice. Generally nitrogen improves the number of tiller, grain filling capacity, number of biomass, harvest index and the final yield of rice crop. Phosphorus is abundantly present in the form of phosphate in cell membranes of the plant, where it plays vital roles in being the constituent of DNA, RNA, and ATP. The rice straw yields increased with increasing rates of P for all the P sources. The response of rice plant in term of straw yields to P sources and application rates were statistically significant. Phosphorus application rates from all P sources had a positive effect on rice straw yields and the increase was attributed to the increased soil P as the soils were initially medium in soil P. So application of phosphorus can increase the yield parameter of rice and finally increase the final yield of rice.

Potassium has many functions in plant nutrition and growth that influence both yield and quality of the crop.

These include regulation of metabolic sugars between plant parts. Some researchers stated that the growth parameters of rice plant were no longer affected by the either source of K fertilization this was because of adequate quantity of K (139 mg kg-1) already in the soil.

Magnesium is a central atom of chlorophyll and therefore plays a major role in plant photosynthesis, and thus its deficiency degrades the chlorophyll content and leaves become yellowish in color, which is known as chlorosis; however, an adequate supply of Mg makes the plant healthy. Low or excess levels of Mg contents in plants may serve diverse impact on photosynthesis. Mg alleviates Al toxicity through functioning of

Mg transporters, which are accountable for its adequate translocation, distribution, and uptake in rice plants.

Calcium is important to every plant for their growth and development and is involved in activating the enzymes, inducing water movement and salt balance in plant cells, and also activating K to control the process of opening and closing of stomata. Calcium boosts the nutrient uptake, improves the plant tissue's resistance, makes cell wall stronger, and contributes to normal root system development. So the availability of calcium can enhance the final yield of rice crop. Generally the presence or absence of macro nutrients can determine the yield of rice crop. But the extreme high or extreme low amount of those nutrients can affect the growth and yield of the rice.

processes such as photosynthesis; activation of enzymes that metabolize carbohydrates for synthesis

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