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Review

A COMPREHENSIVE REVIEW ON RICE (*ORYZA SATIVA* L.): ORGANIC AND INORGANIC SOURCES WITH ZINC ON YIELD ATTRIBUTES AND SOIL HEALTH

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Abstract

Zinc (Zn) deficiency is a common nutritional disorder that adversely affects human health as well as one of the major abiotic factors limiting rice productivity globally. Studies of Zn dynamics and management in rice soils are crucial because rice is a staple food for people in many nations. As a result of climate change, growers are being forced to give up the traditional activity of transplanting rice into flooded soils and replace it with water-saving techniques like aerobic rice culture and alternative wetting and drying systems. Plant development and growth depend on nutrients. In order investigate the role of nutrients, nutrient deficiency, and toxicity in rice, prior works have been evaluated over this review. Rice plants require both macronutrients and micronutrients. Each nutrient has a different character and is involved in various kinds of plant metabolic processes. The disease tolerance or pathogen resistance of plants is influenced by nutrients. Conditions of nutrient toxicity and deficiency interfere with normal plant growth and show identifiable symptoms. Plants require all the essential nutrients in the right proportions for optimum development, growth, and production. The management of its integrated nutrients has many advantages for improving soil fertility and long-term crop productivity. For sustainable and higher rice production, the knowledge provided in this review article will be helpful to rice growers and researchers.

Keywords: FYM (Farm yard manure), Zn (Zinc), Rice, Soil, Yield.

Introduction

More than half of the world's population depends on rice (*Oryza sativa* L.) as their main source of nutrition. According to Muthayya [1], up to 50% of the dietary caloric supply for millions of Asians living in poverty comes from rice. In Africa and Latin America, it is a significant food crop. It is a member of the Gramineae or Poaceae family. In India produced 122.27 million tonnes of rice in 2020–21 with a productivity of 2713 kg per hectare on an area of 43.82 mha. In Uttar Pradesh, productivity was 2759 kg ha-1 under 19.93 mha area in 2020–21, while production was 15.66 million tonnes [2]. Fertilizers must ideally be used based on a soil test. RDF is 150:60:40 (N,P2O5,K2O kg ha-1) for rice crops. Urea, DAP,

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and muriate of potash (MOP) were used, in that order, to apply the necessary amounts of NPK. Nitrogen, an important ingredient for crop growth and shoot development, appears in urea. Due to its high N content (46%N), urea is the most crucial nitrogenous fertilizer in the countries. A concentrated phosphate-based fertilizer, DAP (Di ammonium phosphate), is used. Along with nitrogen, phosphorus is a necessary nutrient that is important for the growth of new plant tissues, roots, and for regulation of the synthesis of proteins in crops. It comprises of 18% nitrogen and 46% phosphorus. Potassium chloride, also known as muriate of potash, contains 60% potassium. Potassium is necessary for healthy plant growth. It is essential for the synthesis of proteins and carbohydrates. By keeping plants' water levels stable, it also provides draught resistance, which benefits photosynthesis by keeping leaves healthy and flexible. Before transplanting, a basal dose of half a dose of nitrogen and full doses of P2O5, K2O, and ZnSO4 should be applied. The remaining half of the nitrogen dose should be given in two split doses; one each at early tillering stage (15-18 DAT) and panicle initiation stage (38-42 DAT). Rice growers have traditionally employed organic materials like FYM. All of the major nutrients—N, P, K, Ca, Mg, and S—as well as the micronutrients—Fe, Mn, Cu, and Zn—necessary for plant growth are provided by FYM. As a result, it serves as a mixed fertilizer.

The micronutrient zinc has been the one most nutrient for the crops, particularly rice, have required in appropriate amounts. Zinc is essential for metabolism and helps in the production of nodules, which are necessary for N-fixation [3].

For many crop plants, zinc belongs among the most crucial nutrients. Zn is crucial for the development of the human immune system and brain function, as well as for enzymatic processes and metabolic processes in plant systems [4].

FYM enhances the physical, chemical, and biological characteristics of soil. A better environment for root development results from the FYM application's improvement in soil structure. FYM increases the ability of soil to hold water. Interest in organic farming has increased due to the fact that the use of organic fertilizers enhances soil structure, nutrient exchange, and maintains soil health [5].

The current levels of crop productivity of high yielding types cannot be sustained by using FYM alone as an alternative to inorganic fertilizer [6]. Therefore, the most efficient way to maintain a healthy and sustainably productive soil is through integrated nutrient management, which uses both organic manures and inorganic fertilizers at the same time. A growing body of research suggested that a method to overcoming soil fertility limits involves integrated soil fertility management, which makes prudent use of both combined organic and inorganic resources. The use of integrated nutrient management is required due to the high expense of making inorganic fertilizers available to Ethiopian farmers and the presence of cattle in the nation.

Effect of Organic, Inorganic and Zinc fertilizers on Growth attributes of Rice

In rice-wheat cropping systems, the addition of compost with chemical fertilizer increased the biomass and grain yield of rice crops [7]. Further investigation by Ranjitha [8] revealed that the application of the 50% recommended dose of nitrogen through urea + 50% recommended dose of nitrogen through vermicompost significantly increased rice grain and straw yield. When NPK was applied along with farm yard manure, vermicompost, or poultry manure, respectively, the yield of straw from rice was found to be 3.7, 15.9, and 20.7% higher than when NPK was applied alone [9]. Further, Larijani and Hoseini [10] observed that more tillers (28%), panicles (60%), filled grains (20.6%), spikelets (19.6%), and grain yield with combined use of organic and inorganic fertilizer compared with inorganic fertilizer alone.

In the first year of the experiment, applying the entire recommended dose of nitrogen from urea had a significant impact on the yield of rice; however, in the second year of the experiment, applying the full recommended dose of nitrogen from vermicompost and the remaining from chemical fertilizer (urea) resulted in the highest grain and straw yield of rice in the rice-wheat cropping system [11]. The number of panicles (20.50%), panicle length (23.12%), panicle weight (13.02%), 1000 grain weight (12.90%), grain yield (31.15%), and straw yield (37.12%) were also reported to be better upon the application of 125% RDF + 5 t ha-1 vermicompost compared to the control and the individual nutrient sources [12]. Furthermore, the average rice grain yield over the duration of three years revealed that the PM + 30 kg N and PM + 22.5-15-15 kg N: P2O5: K2O treatments significantly exceeded the other treatments [13].

Zn application to plants is essential, as shown by the significant increases in rice biological yield caused by Zn application. In spite of the amount of Zn was applied, the effects of Zn on each yield component were related to one another, growth parameters, and chlorophyll contents. The impact of zinc on yield parameters, however, was slightly greater than that on growth parameters. These findings suggest that Zn nutrition is more crucial for yield than for vegetative growth. Zn deficiency affects plant growth by reducing photosynthate translocation through vascular bundles of petioles, resulting in stunted growth and abnormal reproductive development. Furthermore, Zn application totally depends on time of application. For instance, applying 25 kg ZnSO4 ha-1 at tillering and transplanting was effective, other than panicle initiation was ineffective [14] or crops are deficient in Zn can corrected by Zn application.

Effect of Organic, Inorganic and Zinc fertilizers on soil Health under Rice

The sustained and restored soil fertility in terms of its available nutrients and significant physical and chemical characteristics of the soil were made possible by the integrated application of inorganic fertilizers and organic manures with micronutrients [15]. Similar to the way FYM and inorganic N and P fertilizers were applied together, the improved chemical and physical properties may result in increased and sustainable rice production [16]. Additionally, a comprehensive impact on all physico-chemical properties as well as the soil's availability of nutrients could be responsible for of the higher yield and yield attributes of rice grown with combined nutrient use as compared with 50% RDF through inorganic fertilizers or 100% RDN through FYM and also that provided in maintaining better soil physical condition and continuous supply of nutrients throughout the crop growth [17].

Dubey [18] revealed that under 100% organics and integrated nutrient management, the bulk density of soil and the available P and K contents almost maintained their parental status after the fourth crop cycle, whereas 100% inorganic showed a decrease in P and K as well as an increase in bulk density. Also, the use of compost, green manure, wheat cut straw, and farm yard manure together with chemical fertilizers enhances the physical characteristics of soil, such as its ability to hold water, its rate of infiltration, its level of available moisture, its microbial population, its resistance to penetration, and its bulk density and soil strength [19] Further studies showed that applying FYM (10 t ha-1) along with chemical amendments significantly improved the physical characteristics of a saline-sodic soil, including bulk density, porosity, void ratio, water permeability, and hydraulic conductivity [20].

A combination of one part of the treatment receiving only RDF, all integrated nutrient sources showed an increase in soil organic carbon, available P2O5, and K2O content when compared to the initial values [21]. After harvesting rice and in a rice-wheat cropping system, Sarwar et al. (2008) observed that application of a higher level of compost alone and in combination with chemical fertilizer at the same level decreased the soil pH and sodium absorption ratio while significantly increasing electrical conductivity, available phosphorus, water soluble K, and organic matter status of the soil.

Compared to the recommended level of 90 kg N ha-1 of inorganic nitrogen fertilizer, Nyalemegbe [22] found that cow dung and poultry manure applied at half the recommended rates—10 t ha-1 CD plus 45 kg N ha-1 urea and 10 t ha-1 PM plus 60 kg N ha-1 urea—improved soil physical properties, soil fertility, and soil pH/redox potential. It appears from the study that applying vermicompost and biofertilizer alongside NPK increased the amount of organic carbon, readily available N, P, K, and micronutrient status in soil compared to RD of NPK alone.

Sarwar [7] also revealed that a slight increase in electrical conductivity (ECe) of normal soil and ECe of saline sodic soil decreased in combined application of organic manure and gypsum due to the leaching of salts as a result of improved soil physical conditions.

Interaction of Zinc between Nitrogen and Phosphorus

Recent investigation has shown that increasing the N status of crops may have a significant impact on root Zn uptake, distribution, and accumulation in edible parts. As a result, crop biofortification strategies must take N nutrition into particular consideration in addition to Zn nutrition [23].

Under flooded conditions, using the right source of N may help to increase the availability of Zn in soil. In addition to lowering rhizosphere pH and reducing N losses, application of urea- or ammonium-based fertilizer was more efficient than nitrate-based fertilizers [24]. Increased H+ extrusion by rice roots under submerged conditions increases plant Zn availability [25]. When roots take up NH4 + -N, they release H+ into the rhizosphere; in contrast, when rice is grown aerobically, plants take up NO3 - -N and release OH-, which raises the pH of the rhizosphere and reduces the availability of Zn. Reduced Zn uptake was noticed in the field as a result of the change in N dynamics under aerobic conditions [26].

Although N fertilization may increase Zn uptake by enhancing root and plant growth [27], its effects on the mechanisms that increase grain Zn are still unknown. Additionally, N-use efficiency is less efficient under alternate wetting and drying than it is in an aerobic or lowland flooded system; the reasons for the variation in N-use efficiency need to be elucidated. More than 50% of rice-growing soils worldwide are either calcareous or alkaline in nature (such as in South Asia), or both. As a result, it is crucial to optimize the rate and timing of N application in combination with Zn in order to increase soil Zn availability and, as a result, Zn bringing into grain.

High soil P availability also reduces zinc availability. According to [28&29] Olsen and Haldar, phosphorus interacts with zinc in soil to reduce the amount of zinc that is transferred from roots to shoots, and an imbalanced P:Zn ratio is hazardous for yield. In a greenhouse growing rice in soil, Mandal and Mandal [30] compared the effects of various P fertilization on the transformation of naturally occurring and applied Zn. Application of P increased soil Zn bound forms while immediately decreasing exchangeable and water-soluble Zn. Other investigation also showed that P application influenced Zn uptake by rice and translocated into shoots or stem [31].

The interaction of P-Zn was found to be both additive and antagonistic, and it may change depending on the particulars of the experiment. However, under lowland instead of aerobic or AWD conditions, these interactions have not been thoroughly investigated. In addition, studies on Zn availability in rice systems, particularly in aerobic rice systems, are limited. The majority of studies only discuss Zn-P interaction or individual P or Zn effects on crop growth, yield, and tissue concentration.

Conclusions

In modern agriculture, nutrient management and method of fertilizers application are most significant factors that affects plant growth attributes, yield and quality of grain. The result of some field investigation illustrate that the application of organic manure and inorganic fertilizers enhanced no. of tillers, length of panicles and grain yield as well as improved physicochemical properties of rice grain and also soil. Zn application significantly increased the growth attributes, chlorophyll contents and yield components as well as Zn in rice plants. Generally, Zn at higher level give a higher response. From the investigations of experiment, the use of Zn is suggested for better yield in rice crop. And also, organic manure such as FYM, Vermicompost, green manure and poultry manure are improved physical conditions of soil and restoration of soil fertility. To prevent ecological problems, more research should be done to identify new application approaches and the proper amount of fertilizer to apply based on the type of crop, the characteristics of the soil, and the climate of the region.

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