Full Length Research Paper

Effect of soil-applied and foliar fertilizer on rice
(Oryza sativa)

Alice Afrakomah Amoah* and Collins Kofi Tetteh

Department of Crop and Soil Sciences, Faculty of Agriculture, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

Received 1 April, 2022; Accepted 20 July, 2022

Utilization of foliar fertilizer is not a common practice in field crop production in Ghana, upon this background this research was carried out to assess the combined effect of soil-applied and foliar fertilizer on growth and yield parameters of rice. Four treatments comprising of a control, soil-applied fertilizer and three others comprising of a combination of soil-applied and foliar fertilizer were used. The analyzed results showed some significant differences in growth and yield parameters measured. Treatments that received the combination of soil-applied and foliar fertilizer performed better than the treatment that received the soil-applied fertilizer alone. Amongst the three treatment that received the combination of soil-applied and foliar fertilizer, T3 (soil-applied fertilizer + 150ml Boost-Extra/15l H2O) performed better than its counterparts. The results suggest that the combination of soil-applied fertilizer as basal and 150 ml Boost-Extra/15l H2O at panicle initiation stage is an option that can be adopted in the cultivation of rice.

Key words: Foliar fertilizer, boost-extra, Amankwatia rice, soil-applied fertilizer.

INTRODUCTION

Foliar fertilizers are fertilizers that are applied to foliage to boost nutrient concentration in crops and to correct nutrient deficiencies, as well as to enhance the plant growth.

Foliar spraying has long been used in agricultural production (Eichert et al., 1999). The main benefit of foliar spraying is that it can have up to a 90% efficiency rate of uptake as opposed to 10% efficiency from soil applications. This makes them perfect for correcting nutrient deficiencies. Soil amendments may take several days to take effect and the nutrients may be tied up with other elements and made unavailable to the plant.

Foliar application can also reduce the lag time between application and uptake of the plant (Ahmad and Jabeen, 2005).

Furthermore, it is an economical way of supplementing the plant’s nutrients when they are in short supply or unavailable from the soils and it has been shown that the efficiency of foliar application is three-five folds greater than soil-applied fertilizers, and can thus significantly reduce the amount of fertilizer usage. According to (Kerin and Berova, 2003; Fageria et al., 2009; Kannan, 2010),

*Corresponding author. E-mail: alice_amoah@ymail.com. Tel: +233 – 244784857.

Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International License
most foliar fertilizers do not contain impurities that can damage plants and also cause accumulation of toxic residues because they are hundred percent water soluble. Sharply et al. (1994) had reported the reduction of phosphorus contamination of lakes and streams compared with soil application of phosphorus. This indicates the great potential of foliar fertilization as a means of reducing soil and ground water pollution. In addition, it can be mixed with pesticide and sprayed to reduce cost (Witek, 2000).

Rice (*Oryza sativa* L.) is a staple food for more than half of the world’s population (Vibhuti et al., 2015). Globally, rice is grown on 161 million hectares, with an average annual production of 767.7 million tonnes (Bargali et al., 2009).

Currently in Sub Saharan Africa (SSA), rice is the second largest source of caloric intake after maize, and it is anticipated that demand will increase continuously given the high rate of population growth and rapid urbanization in the region (Balasubramanian et al., 2007).

In recent times, rice has become one of the main staples in Ghana, but most of the consumption is met by imports (MOFA, 2010). According to Duffuor (2009), the country imported over 350,000 tons of milled rice worth 600 million US dollars. The high dependence of Ghana and the West African sub-region on imported rice has attracted the attention of governments, donors, civil society organizations, the media and scientists (MOFA, 2008; Nwanze et al., 2006; JICA, 2008; Mohapatra, 2011).

Utilization of foliar fertilizers is not common in field crop production in Ghana despite its advantages. Many field crops farmers in Ghana especially those who are into rice production are adapted to soil-applied fertilizers than foliar fertilizers. This practice as known creates numerous problems to the soil, the plants, the environment. To reduce these problems, there is the need for foliar fertilizers to be introduced into the cropping system. To achieve this, it is imperative to study the effect of foliar and soil-applied fertilizers. Haytova (2013) reported that, initial soil application of nutrient, and foliar application of subsequent nutrients would help reduce the problems associated with depending solely on soil-applied fertilizers.

Based on these issues, this research was carried out to evaluate, the effect of foliar fertilizer and soil-applied fertilizer on the growth and yield parameters of rice.

**MATERIALS AND METHODS**

**Plant culture**

A pot research was done from October 2019 to February 2020 at the Plantation crops and Experimentation section of the Department of Crop and Soil Sciences, Faculty of Agriculture, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana (latitude 06° 43’ N and longitude 01° 33’ W). The chemical characteristics of the soil and nutrient concentration of the foliar fertilizer used are shown in Tables 1 and 2 respectively. Four treatments comprising of a control (Recommended fertilizer application rate for farmers) and three others which are the combinations of soil-applied and foliar fertilizer were used. Details of the treatments are shown in Table 3. A local rice variety Amankwata which was obtained from CSRI-Crop Research Institute, Fumesua, Kumasi was used as a test crop. 12 litre size plastic pots were filled with 13.1 kg sieved top soil and watered to field capacity. Two, twenty-one (21) days old rice seedlings, were transplanted into each pot. One week after transplanting, the required quantity of NPK 15: 15: 15 fertilizer was applied to each of the treatments as basal and seven weeks after transplanting (WAT), the required quantity of nitrogen (Urea) was applied to T1 as top dressing during the panicle initiation stage. For T2, T3 and T4, the required volume of the foliar fertilizer (Boost Extra) was mixed in a knapsack sprayer and sprayed onto the leaves during the panicle initiation stage. Based on calculation, 100ml Boost Extra/15L H2O was applied to the 5 pots under treatment two (T2), 150ml Boost Extra/15L H2O was applied to the 5 pot under treatment three (T3) and 200ml Boost Extra/15L H2O was applied to the five pots under treatment four (T4). During the foliar fertilizer application, treatments were shield to prevent droplets from getting onto the other treatments. The crops were irrigated as required throughout the cultivation. All other agronomic requirements were done as and when necessary. The treatments were arranged in a completely randomized design (CRD) and replicated five times.

**Measurements**

A sample of the soil was taken for chemical analysis. Total Nitrogen and available Phosphorus were determined by the Kjeldahl and Bray-1 method respectively. Exchangeable cations; potassium was determined by the flame photometer method, and Ca2+ and Mg2+ were determined by the EDTA titration method (Moss, 1961). Data collection started four weeks after transplanting through to harvest. A chlorophyll meter model (CCM-200 PLUS) was used to measure the chlorophyll content on ten fully expanded leaves at the peak growth stage. Plant height was measured using a wooden rule (100 cm) from the soil level to the longest tip of the leaf. Plants were harvested at the physiological maturity stage. Plant shoots were cut at soil level at harvest and air dried for seven days and weighed. Five crops per treatment were harvested for yield components and yield analysis. Climatic information during the cultivation period was obtained from KNUST meteorological station.

**Statistical analysis**

All data collected were analyzed with ANOVA using GENSTAT 12th Edition and differences among treatment means was determined by the Least Significant Difference (LSD) test at 5% probability.

**RESULTS**

The climatic conditions during the period of the experiment are presented in Table 4. On the whole the temperature regime was favorable for the crops. The plant height, number of tillers and straw weight are presented in Table 5. For all these parameters measured, no significant difference was observed between T2, T3 and T4. They were all at par and significantly different from T1. For the chlorophyll content (Table 5), no significant difference was observed...
### Table 1. Chemical characteristics of the soil used.

| Property                      | Soil  |
|-------------------------------|-------|
| pH                            | 6.28  |
| Total Nitrogen N (%)          | 0.383 |
| Available phosphorus P (mg/kg) | 2.926 |
| Exchangeable potassium K (cmol+/kg) | 0.095 |
| Exchangeable calcium Ca (cmol+/kg) | 3.400 |
| Exchangeable magnesium Mg (cmol+/kg) | 0.300 |

Source: Authors

### Table 2. Chemical properties of the foliar fertilizer (Boost Xtra) (wt/vol) according to the label.

| Parameter                        | Values (%) |
|----------------------------------|------------|
| pH (H₂O) (10% Solution)          | 4.0-4.5    |
| Nitrogen (N)                     | 20         |
| Phosphate (P)                    | 20         |
| Potassium (K)                    | 20         |
| Magnesium (Mg)                   | 1.5        |
| Iron EDTA (Fe)                   | 0.15       |
| Manganese EDTA (Mn)              | 0.075      |
| Copper EDTA (Cu)                 | 0.075      |
| Zinc EDTA (Zn)                   | 0.075      |
| Boron (B)                        | 0.0315     |
| Cobalt EDTA (Co)                 | 0.0012     |
| Molybdenum (Mo)                  | 0.0012     |

Source: Authors

### Table 3. Treatment details and abbreviations.

| Treatment                                                                 | Abbreviation |
|---------------------------------------------------------------------------|--------------|
| Control 100kg/ac NPK basal + 50kg/ac Urea at panicle initiation            | T1           |
| 100kg/ac NPK basal + 100ml/15L H₂O Boost Extra at panicle initiation      | T2           |
| 100kg/ac NPK basal + 150ml/15L H₂O Boost Extra at panicle initiation      | T3           |
| 100kg/ac NPK basal + 200ml/15L H₂O Boost Extra at panicle initiation      | T4           |

T1 Recommended rate for farmers, T2: 100ml/15L H₂O Boost Extra = (2L/ha Boost Extra), T3: 150ml/15L H₂O Boost Extra = (3L/ha Boost Extra), T4: 200ml/15L H₂O Boost Extra = (4L/ha Boost Extra).

Source: Authors

between all the treatments. For number of tillers, T3 had the highest number of tillers followed by T2 and T4 which were all statistically the same but significantly different from T1 which had the lowest number of tillers. The same trend was observed for the number of panicles per plant (Table 6). For the number of grains per panicle (Table 6), T3 had the highest value followed by T2 which were both significantly the same. T3 was significantly different from T1 and T4 which had lower number of grains per panicle.

The percentage ripened grains results as presented in Table (6), also shows T3 having the highest number of ripened grains followed by T2 and T4, but being significantly the same. T1 had the lowest percentage ripened grains and was significantly different from T3. 1000-grain weight results (Table 6) showed no significant difference among all the treatments, though T3 had the greatest weight. For the grain yield, T3 still recorded the highest grain yield followed by its counterparts T2 and T4.
Table 4. Climatic observation during the experimental period.

| Year   | Month  | Maximum temp (°C) | Minimum temp (°C) | Mean temp (°C) | Total rainfall (mm) | Relative humidity (%) |
|--------|--------|-------------------|-------------------|----------------|---------------------|---------------------|
| 2019   | August | 29.1              | 21.5              | 25.1           | 24.8                | 86                  |
|        | September | 30.2          | 22.2              | 26.2           | 158.1               | 88                  |
|        | October  | 30.9             | 22.3              | 26.6           | 316.6               | 86                  |
|        | November | 33.3            | 22.9              | 28.1           | 8.8                 | 82                  |
|        | December | 33.5            | 22.9              | 28.2           | 41.8                | 82                  |
|        | January  | 34.6             | 21.3              | 28.0           | 00.0                | 71                  |
|        | February | 36.1            | 22.3              | 29.2           | 00.0                | 74                  |
| 2020   | March   | 34.8             | 23.3              | 29.1           | 124.1               | 80                  |
|        | April   | 33.5             | 23.0              | 28.3           | 96.6                | 80                  |
|        | May     | 33.1             | 22.9              | 28.0           | 165.3               | 82                  |

Source: Meteo station, KNUST.

Table 5. Effect of treatment on growth components and chlorophyll content.

| Treatment | Height (cm) | Number of tillers per plant | Straw weight (g) | Chlorophyll content |
|-----------|-------------|-----------------------------|------------------|--------------------|
| T1        | 63.1b       | 10.40b                      | 31b              | 22a                |
| T2        | 73.48ab     | 23.60a                      | 52a              | 24a                |
| T3        | 77.80a      | 29.00a                      | 56a              | 22a                |
| T4        | 75.74a      | 21.80a                      | 45a              | 20a                |

The same letter(s) means no significant difference among treatment means at 5% LSD.
Source: Authors

Table 6. Effect of treatment yield parameters and grain yield.

| Treatment | No. of panicles per plant | No. of grains per panicle | % Ripened grains | 1000 grains weight (g) | Grain yield (g/m²) |
|-----------|---------------------------|---------------------------|------------------|------------------------|-------------------|
| T1        | 12.0b                     | 90.5b                     | 63.5b            | 24a                    | 538b              |
| T2        | 21.6a                     | 101.5ab                   | 72.9ab           | 26a                    | 1440a             |
| T3        | 23.0a                     | 113.4a                    | 79.4a            | 27a                    | 1837a             |
| T4        | 22.4a                     | 87.3b                     | 70.7ab           | 25a                    | 1218ab            |

The same letter(s) indicates no significant difference among treatment means at 5% LSD.
Source: Authors

and, were significantly different from T1. T4 was an intermediary being at par with T1. Cost estimates for each fertilizer treatment is presented in Figure 1. The cost estimates show that, application of soil-applied fertilizer is expensive compared to applying the foliar fertilizer combined with the soil-applied fertilizer.

DISCUSSION

At the end of the experiment, treatments that received the combination of soil-applied and foliar fertilizer performed better than the treatment that received the soil-applied fertilizer alone. Though other factors could have contributed to the low performance of T1 and not specifically the soil applied fertilizer alone. Plant height was significantly higher for the treatments that received the combination of soil-applied fertilizer and foliar fertilizer (T2, T3, T4). The same trend was observed for the straw weight. This could be attributed to the micronutrients in the foliar fertilizer applied.

The tillering capacity of the treatments that received soil-applied fertilizer as basal and later foliar fertilizer at the panicle initiation stage (T2, T3 and T4) all performed better than T1 which received the soil-applied fertilizer as basal and at the panicle initiation stage. This result is in
conformity with the findings of Budhar and Palaniappan (1996) who did a work on rice and reported that, foliar application of fertilizers especially nitrogen and micronutrients increased number of tillers per plant and the number of productive tillers of rice. Also, Amand et al. (2017) reported a significant higher number of tillers per plant of rice as were affected by foliar application of micronutrients. Other research though not rice, but cereal crops like wheat also have reported increase in tiller numbers as affected by application of foliar fertilizers. Seth and Mosluh (1981) who researched on wheat reported that, soil application of nutrients at the vegetative stage and foliar application of nutrients at the reproductive stage resulted in an increase in the number of tillers per plant of wheat. Similar finding was also reported by Amal et al. (2011) they reported that foliar applied fertilizers especially nitrogen at the reproductive stage increased the number of tillers per plant of wheat. And this, as they reported might be attributed to the more uptake and utilization of foliar fertilizers by the wheat plant.

The same trend of tiller numbers was observed for the number of panicles as well, with T3, T4 and T2 producing more panicles than T1. This trend is not quite surprising as panicles are produced from tillers therefore the output of tillers usually reflect on the number of panicles. This may be as a result of the ease and rapid utilization of the foliar fertilizer by the rice plant. And it agrees with the findings of Bhuyan et al. (2012), who reported that foliar fertilizers increased the number of panicles per plant of rice. The result is also in agreement with the finding of Soylu et al. (2005) and Kenbaev and Sade (2002). They reported that number of panicles per plant is significantly increased by foliar application of different micronutrients on wheat and barley respectively.

Number of grains per panicle for T2 and T3 were statistically the same although T3 had the highest in terms of numerical values, and significantly different from T1 and T4. T4 was statistically at par with T1. The foliar fertilizer affected the number of grains per panicle significantly. This may be due to an increased in dry matter accumulation as a result of high nutrients absorption by the leaves. This result is in line with the findings of Borrell et al. (1998) who did a research on Aman rice and reported that, foliar application of nutrients resulted in a higher increase in the number of grains per panicle of Aman rice. The result is also in support of the findings of Akhtar et al. (2003). They reported that, the number of grains per panicle of rice increased following the foliar application of fertilizer. Bhuyan et al. (2012) reported a higher number of grains per panicle of rice as was affected by foliar spray.

Treatments that received the combination of soil-applied and foliar fertilizers (T2, T3 and T4) had higher percentage ripened grains compared to that which received the soil-applied fertilizer alone (T1). This could be attributed to the micronutrients in the foliar fertilizer which might have cause better assimilates production.

![Figure 1. Total cost of fertilizer for each treatment. Source: Authors](image-url)
and availability during the reproductive phase of the rice crops resulting in better grain filling. As suggested by (Gifford and Evans, 1981; Kush and Peng, 1996; Xu et al., 1997), adequate supply of assimilate and proper accumulation of assimilate during early grain filling rapidly increase grain ripening, as assimilate supply is a key factor in determining ripening in rice.

Grain yield was also higher for the combination of soil-applied and foliar fertilized crops as compared to the soil-applied fertilizer alone. Amongst the three, T3 had the highest yield followed by T2 and T4 although all were at par statistically. This suggests that basal application of soil-applied fertilizer and topdressing with 150ml /15l foliar fertilizer (T3) is better than the others. The overall performance of the combined soil-applied and foliar fertilizer applied treatments can be attributed to the micronutrients in the foliar fertilizer applied, resulting in good grains per panicle production and grain filling, all culminating into good grain yield. Similar reports of increase in grain yield have been reported by Bhuyan et al. (2012) who stated that, foliar application of N fertilizer increased grain yield of Aman rice as compared to the conventional method (soil fertilization). The result is also in support with that of Hobbs and Gupta (2003) who reported that, foliar application of fertilizer elements increased grain yield of Aman rice and wheat. Bybordi (2014), who conducted an experiment on rice, reported that foliar application of micronutrients depicted more promising results. Other researches have reported on a similar cereal crop like wheat. For instance, Barut (2019), who did a research on wheat, indicated that foliar fertilizer treatments had positive effects on grain yield and quality of wheat.

Hamouda et al. (2015) also reported a similar finding. Mesdah (2009) had also reported higher grain yield of wheat as was affected by the application of foliar fertilizer nutrients.

The lower value recorded by treatment one (T1) could be attributed to the fact that the soil-applied fertilizer lack micronutrients such as zinc, copper, sulfur, etc. and as reported by Sohota (2006), insufficient levels of micronutrients like sulfur prevent grain cereals from reaching their yield potential.

It could be concluded based on the present findings that, foliar fertilizer treatments as topdressing, during the panicle initiation stage generally had positive effects on the rice crop. In this experiment, foliar fertilizer rates at 100ml Boost-Extra/15l H2O (T2), 150ml Boost-Extra/15l H2O (T3) and 200ml Boost-Extra/15l H2O (T4) significantly affected the growth and yield parameters of Amankwaia rice variety. Foliar fertilizer at a rate of 150ml/15l H2O (T3) was the best. The soil-applied fertilizer had no significant effect on the growth and yield of parameters of the rice variety.

Also cost estimates for each treatment shows that, it cost less to apply the combination of the soil-applied and foliar fertilizer compared to applying the soil-applied fertilizer alone.

Conclusion

On the whole, the results suggest that the combination of soil-applied fertilizer as basal and 150ml Boost-Extra/15l H2O at panicle initiation stage is an option that can be adopted in the cultivation of rice.

CONFLICT OF INTEREST

The authors have not declared any conflicts of interests.

REFERENCES

Ahmad R, Jabeen R (2005). Foliar spray of mineral elements antagonistic to sodium—a technique to induce salt tolerance in plants growing under saline conditions, Pakistan Journal of Botany 37(4):913-920.

Akhtar ME, Saleem MT, Stauffer MD (2003). Potassium in Pakistan agriculture. Pakistan Agriculture Research Council. Research Council Islamabad pp. 9-11.

Amal GA, Tawilk MM, Hassanein MS (2011). Foliar feeding of potassium and Urea for maximizing wheat productivity in sandy soil. Australian Journal of Basic and Applied Sciences 5(5):1197-1203.

Amand M, Ankit T, Manoj K, Deepak P, Singh A, Singh B (2017). Effect of foliar spray of various nutrients on rainfall rice. Journal of Pharmacognosy and Phytochemistry 6(5):2252-2256.

Balasubramanian V, Sie M, Hijmans JJ, Otsuka (2007). ‘Increasing Rice Production in Sub-saharan Africa: Challenges and Opportunities’. Advances in Agronomy 94(1):55-133.

Barut H (2019). Effect of foliar urea, potassium and zinc sulfate treatment on grain yield, technical quality and nutrient concentration of wheat. Applied Ecology and Environmental Research 17(2):4325-4342.

Bargali SS, Bargali K, Singh L, Ghosh L, Larkhera ML (2009). Acacia nilotica based traditional agroforestry system: effect on paddy crop management. Current Science 96(4):581-587.

Bhuyan MM, Ferdousi R, Igbal MT (2012). Effect of spray of nitrogen fertilizer on transplanted Aman Rice. International Journal of plant nutrition pp. 2-8, ISRN Agronomy, doi:10.5402/2012/184953.

Borrell AK, Kelly M, Van DE (1998). Improving management of rice in semi-arid eastern Indonesia: responses to irrigation, plant type and nitrogen. Australian Journal of Experimental Agriculture 38(3):261-271.

Budhar MM, Palanippan SP (1996). Effects of integration of Foliar fertilizers on growth and yield attributes of lowland rice. Journal of Agronomy and Crop Science 176:183-187.

Bybordi A (2014). Efficiency of integrated fertilizer management to improve agronomic and physiological traits of rice. Archives of Agronomy and Soil Science 60(7):935-950.

Dufftor K (2009). Budget Statement and Economic Policy of the Government of Ghana for the 2010 Fiscal Year.

Eichert T, Burkhartd J, Novel A (1999). Model System for the Assessment of Foliar Fertilizer Efficiency. In Proceedings of 2nd Intl. Workshop on Foliar Fertilization Suwanart, A., Ed.; Bangkok, Thailand: pp. 41-54.

Fageria NK, Barbosa Filho MP, Moreoa A, Guimaraes CM (2009). Foliar fertilization of crop plants. Journal of Plant Nutrition 32:1044-1064.

Gifford RM, Evans LT (1981). Photosynthesis, carbon partitioning and yield. Annual Review of Plant Physiology 32(1):485-509.

Hamouda HA, EL-Dahshouri, Manal MF, Thaloth AT (2015). Growth, yield and nutrient status of wheat plant as affected by foliar of potassium and iron in sandy soil. International Journal of Chemtech Research 8(4):1473-1491.

Haytova D (2013). Quality of fruits of zucchini squash in the application of foliar fertilizers, Ecology and Future 11(1):28-32.

Hobbs RR, Gupta RK (2003). Resource-Conserving Technologies for...
Wheat in the Rice–Wheat System. Improving the Productivity and Sustainability of Rice-Wheat Systems: Issues and Impacts 65:149-171.

Japanese International Cooperation Agency (JICA) (2008). Ministry of Food and Agriculture, Republic of Ghana. The study on the promotion of domestic rice in the Republic of Ghana (Final report).

Kannan S (2010). Foliar fertilization for sustainable crop production, Sustainable Agriculture reviews, 1, Genetic Engineering, Biofertilization, Soil quality and Organic Farming 4:371-402.

Kenbaev B, Sade B (2002). Response of field grown barley grown on zinc deficient soil to zinc application. Communication in soil Science and Plant Annual 33(3-4):533-544.

Kerin V, Berova M (2003). Foliar fertilization in plants. Videnov and Son, Sofia (in Bulgarian)

Kush GS, Peng S (1996). Breaking the yield frontier of rice. pp. 36-51. In: M.P. Reynolds et al. (ed.) Increasing yield potential indicas can increase yield potential by about 9%. New in wheat: Breaking the barriers, Ciudad Obregón, Sonora. 26–28 plant type breeding has not yet improved yield potential, March, 1996. International Maize and Wheat Improvement Center, Poor grain filling and low biomass production limit the Mexico, D.F., Mexico.

Mesdah F (2009). Effect of irrigation regimes and foliar spray on yield and yield components of wheat. World Journal of Agricultural Research 5(6):662-669.

Ministry of Foreign Affairs (MOFA) (2000). Report of the Committee on improving the quality of locally produced rice to reduce imports. Ministry of Food and Agriculture, Accra, Ghana.

Ministry of Foreign Affairs (MOFA) (2010). Agriculture in Ghana-Facts and Figures. Statistics, Research and Information Directorate (SRID), Ministry of Food and Agriculture, Accra, Ghana.

Mohapatra S (2011). Africa shifts its focus to producing quality rice to support local farmers and reduce the region’s dependence on rice imports. Rice Today 10(1):36-37.

Nwanze KF, Mohapatra S, Kormawa P, Keya S, Bruce-Oliver S (2006). Rice development in sub-Saharan Africa. Journal of the Science of Food and Agriculture 86(5):675-67.

Seth J, Mosluh KL (1981). Effect of urea spray on wheat in Iraq. Experimental Agriculture 17(3):333-336.

Sharply AN, Chapra SC, Wedepohl R, Reddy KR (1994). Managing Agricultural phosphorus for protection of surface water. Journal of environmental quality 23(3):437-451.

Sohota TS (2006). Importance of sulphur in crop production. Northwest Science 9:10-12.

Soylu S, Sade B, Topal A, Akgun N, Gezgin S (2005). Responses of irrigated durum and bread wheaet cultivars to boron application in low boron calcareous soil. Turkish journal of agriculture and forestry 29(4):275-286.

Vibhuti CS, Bargali K, Bargali SS (2015). Seed germination and seedling growth parameters of rice (Oryza sativa L.) varieties as affected by salt and water stress. Indian Journal of Agricultural Sciences 85(1):102-108.

Witek A (2000). Foliar fertilization of fertilizers as environmentally friendly system of mineral fertilization, VII Mied zynarodowe symposium of Poland.

Xu Y, Ookawa T, Ishihara K (1997). Analysis of dry matter production process and yield formation of rice. Journal of crop science 66(1):42-50.