Journal of Agriculture and Crops
ISSN(e): 2412-6381, ISSN(p): 2413-886X
Vol. 8, Issue. 3, pp: 164-169, 2022
URL: https://arpgweb.com/journal/journal/14
DOI: https://doi.org/10.32861/jac.83.164.169

Academic Research Publishing Group

Original Research | Open Access

Influence of Enhanced Efficiency Fertilizer Formulations on Rice Yield in the Guinea Savanna Zone of Ghana

Abdulai Fuseini
Department of Crop Science, Faculty of Agriculture, University for Development Studies, P. O. Box 1882, Tamale, Ghana

Badii Kongyeli Benjamin (Corresponding Author)
Department of Crop Science, Faculty of Agriculture, University for Development Studies, P. O. Box 1882, Tamale, Ghana
Email: benbadii@uds.edu.gh

Article History
Received: 19 February, 2022
Revised: 29 April, 2022
Accepted: 24 May, 2022
Published: 1 June, 2022

Copyright © 2022 ARPG & Author
This work is licensed under the Creative Commons Attribution International
CC BY: Creative Commons Attribution License 4.0

Abstract

Low soil fertility has been a major constraint to the increased and sustainable rice production in the Guinea savanna zone of Ghana. Studies were conducted in four locations to evaluate the yield of rice under different fertilization regimes. The fields were laid out in a randomized complete block design with four replications for each fertilizer treatment. Data were collected on grain yield and seed mass, and subjected to analysis of variance, with treatment means separated at a 5% level of significance. Significant improvement in rice grain yield was realized in all study locations due to the fertilizer treatments. Grain yield improvement of up to 4,280 kg/ha was obtained. The best two performing fertilization regimes in improving rice grain yield were UNIK-CLB+AMI and ACT-CLB+AMI. In general, rice grain yield among treatments containing CropLiftBio (CLB) foliar treatments was statistically similar. Application of ACT+URE or UNIK+ACT with no the CropLiftBio foliar supplementation consistently demonstrated lower grain yields in rice compared to the other fertilizer treatments. Rice grain mass was, however, not significantly impacted by the fertilization regimes in all study locations. From the results of this study, Activa fertilizers used as basal treatment was unsuitable for rice production in the ecology as these generally provided lower grain yields. For maximum grain yield in rice, UNIK (NPK 15:15:15) fertilizer was the most recommended. The basal application of UNIK at 125 kg/ha and topdressing with Amidas at 125 kg/ha with CropLiftBio foliar supplementation will provide better yields for farmers than applying any of the formulations with Activa as a topdress.

Keywords: Efficiency fertilizers; Grain yield; Oryza sativa; Ghana; Savanna ecology.

1. Introduction

Rice is among the most important and widely consumed staple food in tropical Africa (FAO, 2020). In the savanna ecology of Ghana, the average yield of rice (about 1.5 t/ha) is below achievable yields of up to 6.0 t/ha [1]. Rice is produced predominantly by smallholder, resource-poor farmers under rain-fed conditions [2]. Sun, *et al.* [3], reported that rice is most popular cereal crop in northern Ghana due to its economic importance, high yield and low cost of production. However, the average yield of about 1.5 t/ha is below the achievable yields of up to 6 t/ha [1]. Soil fertility is crucial in increasing cereal crop yields, and low soil fertility and low application of external inputs are the major factors affecting productivity of rice [4], and these account for the low yield of the crop. Improving yields through increased productivity of the savanna soils can be achieved by external inputs of nutrients which are available mainly in the form of organic and inorganic fertilizers [5].

Across the north of Ghana, the most sourced of inorganic fertilizers are commercial fertilizers, which are easily accessible to farmers at the local markets. The main limiting nutrients in the soils of the major rice growing areas in northern Ghana have been organic carbon (< 0.2 %), and exchangeable potassium (< 10 mg/kg) [6]. For many decades, a one-cap-fits-all fertilizer recommendations have been made for rice and other crops in Ghana [7]. Moreover, soil conditions are dynamic over the years and the old recommendations are not always efficient. Hence, the need to constantly update or make site-specific fertilizer recommendations for rice production in the northern agroecological zone of Ghana.

Over the years, use of NPK fertilizers have been the primary means of nutrient replenishment. This is understandable as NPK remains the most important nutrients required for cereal crop production [6]. Sole application of NPK has helped to increase rice yield significantly. However, some room remains for further yield increment. It has been postulated that the inclusion of secondary nutrients such as sulphur (S) and micro nutrients such as boron (B) and Zinc (Zn) in fertilizer blends could increase rice yields sharply, beyond levels achieved by use of sole NPK [7-9]. This postulate has not been confirmed nor denied in savanna ecology of Ghana. In view of this, fertilizer blends/formulation in northern Ghana remains primarily of N, P and K. The exclusion of secondary and micro-nutrients in such blends could be limiting possible yield increment, particularly in rice. There is the need to study the growth and yield of rice through inclusion of secondary and micro-nutrient elements in fertilizer treatments [10, 11].

YARA Ghana Limited is an agro input company involved in the importation and sale of mineral fertilizers to improve agricultural production and income of farmers. The company has recently introduced standard fertilizer formulations for cereal crop production, namely YaraMila Actyva (23N+10P+5K+2MgO+3S+0.3Zn), Unik-15 (15N+15P+15K+2.2S), YaraVita Croplift Bio (8.5N+3.4P+6K+B+Cu+Mn+Mo+Zn), YaraVera Amidas (40N+5.6S) and YaraBela Sulfan (24N+6S). The comparative agronomic efficacy of these formulations within the different agro ecological zones in northern Ghana remains largely unknown. There is the need to compare the relative productivity of the fertilizer regimes to enable subsequent recommendation to the resource poor farmer for rice production in the ecology. This study sought to establish and compare the yields of rice obtained from treatments with the various fertilizer formulations within the savanna agroecological zone of Ghana.

2. Materials and Methods

2.1. Study Sites

The trial was conducted during the 2021 cropping season in farmers' farms in four locations, namely, Nyankpala, Walewale, Yendi and Damongo, in the northern Guinea savanna zone of Ghana. Generally, the savanna ecology is that of a tropical continental with a single rainy season, usually from May to October (and peaks around late August or early September), followed by an extended dry season [12, 13]. The study locations (N 09.081; W 001.819; 542 msl) share ecological traits characteristic of the Guinea savanna ecological zone. However, there are significant variations in topography, vegetation and soil physical and chemical properties.

2.2. Trial Protocols

The main purpose of the study was to evaluate the effect of the different fertilizer formulations and application rates on the agronomic performance of rice across the four agroecological zones. The different fertilizer protocols evaluated for the crop are presented in Table 1 below:

Table-1. Protocols used for the rice trial, 2021 season

Treatments	Description		
	Basal application at 2 weeks after planting	**Foliar application at beginning of tillering**	**Top dress at panicle initiation**
ACT-CLB+AMI	YaraMila Actyva @250kg/ha	CropLift Bio@ 2l/ha	YaraVera Amidas@125kg/ha
ACT-CLB+URE	YaraMila Actyva @250kg/ha	CropLift Bio@ 2l/ha	Urea@125kg/ha
UNIK-CLB+ACT	UNIK 15:15:15@250kg/ha	CropLift Bio@ 2l/ha	YaraMila Actyva @125kg/ha
UNIK-CLB+AMI	UNIK 15:15:15@250kg/ha	CropLift Bio@ 2l/ha	YaraVera Amidas@125kg/ha
UNIK-CLB+URE	UNIK 15:15:15@250kg/ha	CropLift Bio@ 2l/ha	Urea@125kg/ha
ACT+AMI	YaraMila Actyva @250kg/ha	No fertilizer	YaraVera Amidas@125kg/ha
ACT+URE	YaraMila Actyva @250kg/ha	No fertilizer	Urea@125kg/ha
UNIK+ACT	UNIK 15:15:15@250kg/ha	No fertilizer	YaraMila Actyva @125kg/ha
UNIK+AMI	UNIK 15:15:15@250kg/ha	No fertilizer	YaraVera Amidas@125kg/ha
UNIK+URE	UNIK 15:15:15@250kg/ha	No fertilizer	Urea@125kg/ha
CONTROL	No fertilizer	No fertilizer	No fertilizer

2.3. Trial Locations

The trial was conducted on-farm in four localities, namely Walewale, Yendi, Damongo and Nyankpala, representing the various agro-ecological zones in the north of Ghana. The site selection was based on the extent of cultivation of rice; the more extensive the cultivation of the crop, the higher the probability of selection for the trials. The choice of fields selected depended on willingness of the farm owner to participate the maintenance of the experiment.

2.4. Land Preparation and Field Layout

Stumps and shrubs were initially removed from fields to ease demarcation and ploughing. The field was ploughed with a tractor and manually leveled with a hoe.

The field was demarcated as a single factor experiment laid out in a Randomized Complete Block Design with three replicates for each treatment. Field sizes of 29 m x 19 m and plot sizes of 5 m x 4 m were covered. A 1 m and 2 m alleys were left between treatments in each block and between blocks, respectively.

2.5. Planting and Application of Fertilizer Treatments

The AGRA rice variety was used for planting at all sites. Planting was done between the first and third weeks of July, 2021. Planting was done at four seeds per hill and later thinned to the appropriate plant stands of 3 seedlings per hill after germination.

The broad-spectrum pre-emergence herbicide, Glyphader 480, was used to control the weeds in each field at planting. The basal fertilizer treatments were applied from two weeks after planting as indicated in the protocol.

2.6. Data Collection and Analysis

Sampling for yield data was done after manual harvest of the crops. Harvesting was done on plot bases using hand-held sickle. After harvesting, rice paddy was manually threshed, and winnowed. Threshed grains were air dried to ~13% moisture content by weight. The weighed grains per plot were converted into weight per unit area (kg/ha).

The weight of 1000 grains of paddy was taken to investigate the effect of the nutrient regimes on grain mass.

All the yield data were analyzed using analysis of variance (ANOVA) in GenStat Statistical package 12th edition. The treatment means were separated and compared using the Least Significant Difference (LSD) at 5% level of probability.

3. Results

3.1. Rice Paddy Yield

Rice paddy yield at Nyankpala was significantly affected (P<0.001) by the fertilization regimes (Table 2). Rice paddy yield ranged from 433 kg/ha in the unfertilized (control) plot to 4280 kg/ha in ACT-CLB+ACT. Yield among the fertilizer treatments without CropLiftBio application was not statistically different. Rice crops that received CropLiftBio foliar application gave significantly better yields than those without the foliar fertilizer. Among the foliar treatments, rice grain yield was statistically similar. Average yield increases over the control was 411% in ACT+URE and 888% and 152% in ACT-CLB+AMI.

Also, Rice paddy yield at Walewale was significantly affected (P<0.001) by the fertilization regimes. Grain yield ranged from 320 kg/ha in the unfertilized (control) plot to 4240 kg/ha in UNIK-CLB+AMI plot. All rice plots that received fertilization had significantly higher yields than that of the control. Rice grain yield among the ACT+URE, UNIK+AMI, UNIK+URE, ACT+AMI and UNIK+ACT treatments did not differ significantly. Grain yield among the CropLiftBio treatments were significantly higher than those with no CropLiftBio. Among the CropLiftBio treatments, ACT-CLB+AMI or UNIK-CLB+AMI had the highest yield.

Rice grain yield at Damongo was significantly affected (P<0.001) by the fertilization regimes. Grain yield ranged from 440 kg/ha in the unfertilized (control) plot to 2440 kg/ha in ACT-CLB+AMI plot. With the exception of ACT-CLB+URE, UNIK-CLB+AMI and ACT-CLB+AMI which had significantly higher yield, grain yield from the other fertilizer treatments were statistically similar. There was yield increment of at least 142% in ACT+URE over the control.

Rice paddy yield at Yendi was significantly affected (P<0.001) by the fertilization regimes. Grain yield ranged from 3787 kg/ha in UNIK-CLB+AMI to 1467 kg/ha in the unfertilized (control) plot. With the exception of UNIK+URE, all the rice plots that received fertilization had significantly higher yields than that of the control. Grain yield obtained from ACT-L+URE-L or ACT-CLB+AMI was similar to those from the other fertilizer treatments with no CropLiftBio. Average yield increases of 39% and 158% over the control were recorded from the UNIK+URE and UNIK-CLB+AMI treatments, respectively.

Table-2. Effect of YARA fertilization regimes on rice paddy yield, 2021 cropping season

Fertilizer treatments	**Rice paddy yield (kg/ha)**			
	Nyankpala	**Walewale**	**Damongo**	**Yendi**
CONTROL	433 a	320 a	440 a	1467 a
ACT+URE	2213 b	2120 b	1067 ab	2960 bcd
ACT+AMI	2360 b	2573 b	1600 bc	3027 cd
UNIK+AMI	2213 b	2240 b	1200 b	2693 bc
UNIK+URE	2387 b	2320 b	1707 bcd	2040 ab
UNIK+ACT	2680 b	2627 b	1173 b	2640 bc
UNIK-CLB+URE	3673 c	3560 c	1813 bcd	3733 d
UNIK-CLB+ACT	3787 c	3440 c	1747 bcd	3667 d
ACT-CLB+URE	4027 c	3507 c	2027 cd	2880 bcd
UNIK-CLB+AMI	4107 c	4240 d	2147 cd	3787 d
ACT-CLB+AMI	4280 c	3867 cd	2440 d	2933 bcd
P @ 5%	*0.001*	*0.001*	*0.001*	*0.001*
LSD (0.05)	*657.5*	*539.6*	*695.1*	*860.6*

3.2. Rice Grain Weight

The seed weight of rice obtained from the various fertilization regimes are presented in Table 3. The results on seed weight however, showed that the fertilization regimes had no significant effect on rice 1000 seed weight at

Nyankpala (P=0.14), even though the highest seed weight (25.50 g) was recorded from UNIK-CLB+AMI while the lowest (24.63 g) was recorded from the control.

Similarly, the fertilization regimes had no significant effect on rice 1000 seed weight at Walewale (P=0.95). The highest seed weight (27.53 g) was recorded from UNIK+URE while the lowest (26.80 g) was recorded from ACT-CLB+AMI.

The fertilization regimes had no significant effect on rice 1000 seed weight at Damongo (P=0.44) even though the highest seed weight (27.53 g) was recorded from UNIK+URE while the lowest (26.80 g) was recorded from ACT-CLB+AMI.

Rice 1000 seed weight was not significantly affected by the fertilization regimes at Yendi (P<0.43), even though the highest seed weight (26.97 g) was recorded from UNIK+URE while the lowest (26.13 g) was recorded from the control (Table 3).

Table-3. Effect of YARA fertilization regimes on rice 1000 grain weight of rice, 2021 cropping season

Fertilizer treatments	Rice paddy weight (kg/ha)			
	Nyankpala	Walewale	Damongo	Yendi
CONTROL	25.37 a	27.33 a	26.97 a	26.73 a
ACT+URE	25.30 a	27.47 a	27.10 a	26.87 a
ACT+AMI	24.80 a	27.13 a	26.47 a	26.47 a
UNIK+AMI	24.73 a	27.40 a	26.13 a	26.47 a
UNIK+URE	25.50 a	27.53 a	26.97 a	26.97 a
UNIK+ACT	25.50 a	27.20 a	26.73 a	26.73 a
UNIK-CLB+URE	24.67 a	27.30 a	26.90 a	26.57 a
UNIK-CLB+ACT	25.33 a	27.13 a	26.93 a	26.93 a
ACT-CLB+URE	24.63 a	27.37 a	26.53 a	26.13 a
UNIK-CLB+AMI	25.50 a	27.37 a	26.57 a	26.57 a
ACT-CLB+AMI	25.50 a	26.80 a	26.37 a	26.70 a
P @ 5%	*0.001*	*0.001*	*0.001*	*0.001*
LSD (0.05)	*0.82*	*0.95*	*0.87*	*0.79*

4. Discussion

Results from this study have demonstrated that availability of adequate nutrients could improve growth and yield parameters of rice in the study locations. The higher paddy yield obtained from UNIK-L+AMI-L treatment could be due to the action of NPK, Urea and Sulphur in that fertilizer formulation.. This NPK product (also called T15 or UNIK 15), is composed of NPK 15-15-15 fertilizer, and every granule of T15 contains total N, P, and K nutrient source. Yara UNIK 15 products include a balance of nitrate and ammonium nitrogen, making the products significantly more effective than urea of ammonium-based fertilizers per unit of nitrogen. This formulation is known to dissolve quickly and evenly when in contact with the soil in humid conditions or after a night's dew [14]. In dry climates, the higher solubility of the products helps nutrients reach the roots where limited soil moisture is available. In tropical climates nutrients move rapidly into the soil, avoiding potential for soil surface run-off due to heavy rain, and thus, promoting rice growth and yield productivity [15].

Also, T15's nitrophosphate production process gives the formulation a unique combination of polyphosphates and orthophosphates. These forms give greater availability of soluble phosphate to the rice plant over a wide range of soil types. Moreover, Amidas is made up of 40 N + 5.6 S [16]. This is an improved grade of Urea fertilizer with Suphur supplement [17]. The formulation is a unique granular fertilizer that is 100% soluble and very efficient. The product contains nitrogen and sulphate sulphur that is readily available to the rice crops in an ideal N:S ratio of 7:1. The nitrogen is mostly available in the urea form, making it ideal for rice growth, yield and productivity especially in the relatively poor soils of northern Ghana. Furthermore, the sulphur content of Amidas improves nitrogen efficiency from urea by reducing nitrogen volatilisation losses by up to 35% on low pH soils [18] a property that is generally lacking in our conventional physical blends of urea and ammonium sulphate. Less nutrient losses and the balanced nitrogen and sulphur supply from the Amidas fomulation could ensure consistently high yields of quality grain with minimum environmental impact [19].

On the other hand, Urea (46% N) is a formulation from anhydrous ammonia (NH_3) with high nitrogen (N) analysis of 46% compared to all known N fertilizers. It is made available to the plant after contact with moisture within 48hours of application which is best achieved through soil incorporation [16]. Urea is generally applied alone and is the fertilizer of choice when only N is needed in a fertilizer regime [20]. This may explain its inability to compete favorably with Amidas as a top-dress fertilizer as revealed in this study.

5. Conclusion and Recommendations

Based on the results obtained, the following conclusions were made:

1. Significant improvement in rice paddy yield was realized in all study locations due to the fertilizer treatments. Grain yield improvement ranged from 4,280 kg/ha in Nyankpala to 2,440 kg/ha in Damongo.
2. The best three performing treatments in improving rice grain yield in both Nyankpala and Damongo were UNIK-L+AMI-L, ACT-L+AMI-L and ACT-LURE-L, in descending order.

3. At most locations, rice grain yield among the CropLiftBio foliar treatments was statistically similar.
4. Application of ACT+URE and UNIK+ACT without CropLiftBio foliar supplementation consistently demonstrated lower rice grain yields compared to the other fertilizer treatments in all study locations.
5. Rice paddy weight was however, not significantly impacted by the fertilizer treatments at any of the study locations.

Based on the conclusions raised, the following recommendations were made:

1. From the results of this study, Actyva fertilizers used as basal treatment appear to be unsuitable for rice production in the savanna ecology of Ghana as these generally provided lower grain yields. These formulations are however recommended for top dress applications for moderate yield in rice.
2. For maximum grain yield of rice in the ecology, UNIK 15 (NPK 15:15:15) fertilizer is the most recommended. The basal application of UNIK 15 at 125 kg/ha and topdressing with Amidas at 125 kg/ha with CropLiftBio foliar supplementation will provide better yields for farmers than applying Actyva as topdress.
3. Where Amidas becomes unavailable, however, Urea (46 N) may be used as alternative topdressing product for moderate yield.
4. There is the need to investigate the efficacy of adding UNIK 15, or including Sulfan as possible topdress alternatives for rice production in the ecology.
5. For the smallholder situation where, double application may be a challenge, there is need to consider the efficacy of fertilizing rice with UNIK 15 alone at recommended rate, without any topdress application.

Competing interest

Authors have no conflict of interests

Acknowledgements

YARA Ghana Limited provided funding for the research.

References

[1] Oppong-Abebrese, S., Yeboah, A., Dogbe, W., Ayirebi, D. P. K., Akromah, R., Gracen, V. E., Offei, S. K., and Danquah, E. Y., 2019. "Evaluation of yield, reaction to diseases, and grain physical attributes of some introduced rice hybrids in Ghana." *International Journal of Agronomy,* vol. 3, pp. 78-86.

[2] Kankam-Boadu, I., Sarkodie-Addo, J., and Amagloh, F. K., 2018. "Profitability of maize production in the northern region of Ghana." *International Journal of Development*, vol. 2, pp. 3-10.

[3] Sun, J., Gao, J., Wang, Z., Hu, S., Zhang, F., Bao, H., and Fan, Y., 2019. "Maize canopy photosynthetic efficiency, plant growth, and yield responses to tillage depth." *Agronomy,* vol. 9, pp. 234-242.

[4] MacCarthy, D., Adiku, S. G., Freduah, B. S., Kamara, A. Y., Narh, S., and Abdulai, A. L., 2017. "Evaluating maize yield variability and gaps in two agro-ecologies in northern Ghana using a crop simulation model." *South African Journal of Plant and Soil,* vol. 1, pp. 143-154.

[5] Lisuma, J., Semoka, J., and Sem, E., 2016. "Maize yield response and nutrient uptake after micronutrient application on a volcanic soil." *Agronomy Journal,* vol. 98, pp. 402-406.

[6] Abumere, V. I., Dada, O. A., Adebayo, A. G., Kutu, F. R., and Togun, A. O., 2019. "Different Rates of Chicken Manure and NPK 15-15-15 Enhanced Performance of Sunflower (Helianthus annuus L.) on Ferruginous Soil." *International Journal of Agronomy,* vol. 2, pp. 23-31.

[7] Njoroge, R., Abigael, N., Otinga, John, Okalebo, R., Pepela, M., and Merckx, R., 2018. "Maize (Zea mays L.) Response to secondary and micronutrients for profitable N, P and K fertilizer use in poorly responsive soils." *Agronomy*, vol. 8, pp. 49-59.

[8] Ceyhan, E., Onder, M., Ozturk, O., Marmankaya, M., Hamurcu, M., and Gezgin, S., 2008. "Effects of application of boron on yields, yield component and oil content of sunflower in boron-deficient calcareous soils." *African Journal of Biotechnology,* vol. 7, pp. 2854-2861.

[9] Rudani, L., Vishal, P., and Kalavati, P., 2018. "The importance of zinc in plant growth- a review." *International Research Journal of Natural and Applied Sciences,* vol. 5, pp. 38-48.

[10] Tahir, M., Ali, A., Khalid, F., Naeem, M., Fiaz, N., and Waseem, M., 2012. "Effect of foliar applied boron application on growth, yield and quality of maize (Zea mays L.)." *Pakistan Journal of Scientific and Industrial Research,* vol. 55, pp. 117-121.

[11] Kihara, J., Sileshi, G. W., Nziguheba, G., Kinyua, M., Zingore, S., and Sommer, R., 2017. "Application of secondary nutrients and micronutrients increases crop yields in sub-Saharan Africa." *Agronomy for Sustainable Development,* vol. 37, pp. 5-12.

[12] FAO, 2020. "State of forest genetic resources in Ghana." Available: http://www.fao.org/3/ab388e/ab388e02.htm#TopOfPage

[13] Tetteh, F., Larbi, A., Nketia, K. A., Senayah, J. K., Hoeschle-Zeledon, I., and Abdul-Rahman, N., 2016. "Suitability of soils for cereal cropping in northern ghana." *Evaluations and Recommendations,* Available: https://doi.org/10.13140/RG.2.2.34455.73122

[14] Olowookere, B. T., Oyerinde, A. A., and Malgwi, W. B., 2017. "Influence of Nitrogen and micronutrient fertilizer blends on growth and yield of maize varieties." *Journal of Agriculture Food and Development,* vol. 3, pp. 1-6.

[15] Irfan, M., Abbas, M., Shah, J. A., Depar, N., Y., M. M., and Sial, N. A., 2019. "Interactive effect of phosphorus and boron on plant growth, nutrient accumulation and grain yield of wheat grown on calcareous soil." *Eurosian Journal of Soil Science,* vol. 8, pp. 17-26.

[16] Daphade, S. T., Hanwate, G. R., and Gourkhede, P. H., 2019. "Influence of zn, fe and b applications on nutrient availability in soil at critical growth stages of maize (zea mays) in vertisol of marathawada region of maharashtra, India." *International Journal of Current Microbiology and Applied Sciences,* vol. 8, pp. 206-212.

[17] Fismes, J., Vong, P. C., Guckert, A., and Frossard, E., 2000. "Influence of sulfur on apparent N-use efficiency, yield and quality of oilseed rape (Brassica napus L.) grown on a calcareous soil." *European Journal of Agronomy,* vol. 12, pp. 127–141.

[18] Yigermal, H., Nakachew, K., and Assefa, F., 2019. "Effect of integrated nutrient application on phonological, vegetative growth and yield-related parameters of maize in Ethiopia: A review." *Cogent Food and Agriculture,* vol. 5, pp. 9-18.

[19] Abdulai, F., Badii, K. B., and Nboyine, J. A., 2021. "Comparison of maize yield from different Yara fertilization regimes in four locations in the Guinea savanna zone of Ghana." *Greener Journal of Agricultural Sciences,* vol. 10, pp. 163-172.

[20] Qahar, A. and Ahmad, B., 2016. "Effect of nitrogen and Sulphur on maize hybrids yield and post-harvest soil nitrogen and Sulphur." *Sarhad Journal of Agriculture,* vol. 32, pp. 239-251.