Vol. 19(7), pp. 698-704, July, 2023
DOI: 10.5897/AJAR2023.16341
Article Number: 4B14E8B70913
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

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African Journal of Agricultural Research

Full Length Research Paper

Response of rice (*Oryza sativa* L.) to foliar fertilizer

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Received 15 February, 2023; Accepted 26 May, 2023

This experiment was conducted to evaluate the impact of foliar fertilizer on the growth and yield parameters of rice, due to the fact that foliar fertilizer utilization is not a common practice in field crop production in Ghana. Eight treatments comprising two (Recommended fertilizer application rate for farmers) and six others which are the foliar fertilizer (Boost Xtra foliar fertilizer) were used. The analyzed results showed significant differences in some growth and yield parameters measured. On the whole, performance of the foliar fertilizer treatments compared with the recommended soil-applied fertilizer treatments was good. Amongst the foliar fertilizer treatments also, application of 150 ml Boost Xtra/15l H_2O output was better than its other foliar fertilizer treatments. The entire results suggest that it is possible to utilize foliar fertilizer in the cultivation of rice and also the application of foliar fertilizer at a rate of 150 ml Boost Xtra /15l H_2O either at (basal + panicle initiation) or (basal + panicle initiation + Heading) could be an option for adoption in the cultivation of rice.

Key words: AGRA rice, foliar fertilizer, Boost-Xtra, soil-applied fertilizer.

INTRODUCTION

Foliar fertilization is a way of feeding plants by spraying liquid fertilizer directly to the leaves. Its application has been shown to avoid the problem of leaching-out in soils and prompts a quick reaction in the plant. Its 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) and Kannan (2010), most foliar fertilizers are 100% water soluble, hence they do not contain impurities that could damage plants and also lead to accumulation of toxic residues in the production cycle.

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.

More so, foliar fertilizers in recent times as indicated by Witek (2000) have successfully been mixed with

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Table 1. Chemical characteristics of the soil used.

Property	Soil
pH	6.28
Total nitrogen (%)	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).

Parameter	Values (%)
pH (H_2O) (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
Colbalt EDTA (Co)	0.0012
Molybdenum (Mo)	0.0012

Source: Authors.

commercial pesticides and this helps reduce total production cost.

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 165.25million hectares (Statista, 2023), with production of 515 million tons (USDA, 2022).

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 (Balatsubramamian 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). The country imports over 1.162 billion worth of rice annually (GNA, 2018).

The high dependence of Ghana and the West African sub-region on imported rice has attracted the attention of governments, donors, civil society organization, the media and the scientists (MOFA, 2000; 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 crop farmers in Ghana especially those who are into rice production are more accustomed to soil-applied fertilizers than to foliar fertilizers.

This practice as known can create numerous problems to the soil, plants and environment. To reduce these problems, and also manage the high cost and sometimes the unavailability of soil-applied fertilizers, there is the need for foliar fertilizers to be introduced into the cropping system. To achieve this, it may be helpful to study the effect of foliar fertilizers on rice.

Based on these issues, this experiment was carried out to assess the impact of foliar fertilizer on the growth and yield parameters, and also evaluate the effect of the period of application on the productivity of the rice crop.

MATERIALS AND METHODS

Plant culture

A pot experiment was carried out 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.

Eight treatments comprising two recommended fertilizer application rate for farmers and six others which are the foliar fertilizers (Boost Xtra foliar fertilizer) were used. Details of the treatments are shown in Table 3.

A local rice variety AGRA, obtained from CSRI-Crop Research Institute, Fumesua, Kumasi was used as a test crop.

12 litre size plastic pots were filled with 12.7 kg sieved top soil and watered to field capacity. Two, twenty-one days old rice seedlings, were transplanted into each pot. One week after transplanting, NPK 15: 15: 15 fertilizer was applied to treatment one (T1) and two (T2) as basal and seven weeks after transplanting (WAT), the required quantity of nitrogen (urea) was applied to T1 and T2 as top dressing during the panicle initiation stage. T2 received a third nitrogen application during the heading stage. For T3, T5, T7 the required volume of the foliar fertilizer (Boost Xtra) was mixed in a knapsack sprayer and sprayed onto the leaves for basal and during the panicle initiation stage. T4, T6 and T8 received foliar (Boost Xtra) as basal, during Panicle Initiation and at heading stage. During the foliar fertilizer application, treatments were shielded to prevent droplets from getting onto the other treatments. The crops were irrigated as required throughout the cultivation period. All other agronomic practices were undertaken as required.

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 Ca^{2+} and Mg^{2+} were determined by the EDTA titration method (Moss, 1961).

Data collection started four weeks after transplanting and continued till harvest. Chlorophyll content was measured with a chlorophyll meter model (CCM-200 PLUS) on 10 randomly selected fully expanded leaves at the peak vegetative stage. Plant height was measured using a wooden rule (100 cm) from the soil level to

Table 3. Treatment details and abbreviations.

Treatment	Abbreviation
100 kg NPK /ac basal + 50 kg Urea/ac at panicle initiation	T1
100 kg NPK/ac basal + 25 kg Urea/ac at panicle initiation + 25 kg Urea/ac at Heading	T2
100 ml Boost Xtra /15l H_2O basal +100 ml Boost Xtra /15l H_2O at panicle initiation	T3
100 ml Boost Xtra /15l H_2O basal + 100 ml Boost Xtra /15l H_2O at panicle initiation + 100 ml Boost Xtra /15l H_2O at heading	T4
150 ml Boost Xtra /15l H_2O basal + 150 ml Boost Xtra /15l H_2O at panicle initiation	T5
150 ml Boost Xtra /15l H_2O basal +150 ml Boost Xtra /15l H_2O at panicle initiation + 150 ml Boost Xtra /15l H_2O at heading	T6
200 ml Boost Xtra /15l H_2O basal + 200 ml Boost Xtra /15l H_2O at panicle initiation	T7
200 ml Boost Xtra /15l H_2O basal + 200ml Boost Xtra /15l H_2O at panicle initiation + 200 ml Boost Xtra /15l H_2O at heading	T8

T1 and T2 Recommended rate for farmers, 100ml Boost Xtra /15l H_2O = (2l/ha Boost Xtra), 150ml Boost Xtra /15L H_2O = (3l /ha Boost Xtra), 200ml Boost Xtra /15l H_2O = (4l /ha Boost Xtra).
Source: Authors

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 for each treatment were harvested for yield and yield component analysis. Weather data for the cultivation period were obtained from a weather station situated on the campus of KNUST.

Statistical analysis

All data collected were analyzed with ANOVA using GENSTAT 12th Edition and differences between treatments means were determined by the Least significant difference (LSD) test at 5% probability.

RESULTS

The weather conditions during the period of the experiment are presented in Table 4. On the whole, the temperature regime was favorable for the crops.

Results on growth parameters are presented in Table 5. Plant height had no significant differences between all the treatments. The same trend was observed for the number of tillers per plant though numerically the treatments that received the foliar fertilizer (Boost Xtra) were slightly higher than the treatments that received the soil-applied fertilizer (NPK) that is, T1 and T2.

For the straw weight, significant differences were observed. Treatments that received the foliar fertilizer (Boost Xtra) recorded heavier straw weight compared to T1 and T2 which received soil-applied fertilizer (NPK). Amongst the treatment that received the foliar fertilizer too, treatments that received the 150ml Boost Xtra/15l H_2O (T5 and T6) were slightly heavier than their other counterparts.

Chlorophyll content (Figure 1) also recorded some differences between the foliar fertilizer treatments and the soil-applied treatments. Comparing the stages of growth application, T6 (150ml Boost Xtra/15l H_2O as basal, at panicle initiation (PI) and at heading) was much greener than T2 soil-applied fertilizer (as basal, PI and at heading). T6 was also greener than its foliar counterpart T8 (200ml Boost Xtra/15l H_2O as basal, at PI and at heading). The results for the yield parameters and grain yield are presented in Table 6. For the number of panicles per plant, no significant differences were observed between the treatments though numerically, treatments that received fertilizer at the three stages of growth (as basal, PI, and at heading) had slightly higher number of panicles than the other treatments that received fertilizer at the two stages (at basal and at PI).

No significant difference was observed for the number of grains per panicle also, however, T2 (soil-applied fertilizer) had a greater number of grains per panicle than its foliar fertilizer treatments (T4, T6, T8).

With the % ripened grains, significant differences were observed. T2 recorded the highest % ripened and T3 and T4 recorded the lowest. Amongst the foliar fertilizer treatments also, T3 and T4 (100ml Boost Xtra/15l H_2O) had the lowest % ripened grains compared to its foliar fertilizer counterparts T5, T6 (150ml Boost Xtra/15l H_2O) and T7, T8 (200ml Boost Xtra/15l H_2O). There were no significant differences between the treatments for the 1000 grains weight.

Grain yield recorded some significant difference between the treatments. T2 (soil-applied fertilizer at basal, PI and at Heading) had the highest grain

Table 4. Weather 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
2020	January	34.6	21.3	28.0	00.0	71
	February	36.1	22.3	29.2	00.0	74
	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.

Treatment	Height (cm)	Number of tillers/plants	Straw weight (g)
T1	74.10[a]	13.60[a]	29.90[b]
T2	76.65[a]	15.80[a]	38.30[ab]
T3	72.54[a]	13.20[a]	37.00[ab]
T4	72.86[a]	16.20[a]	45.30[ab]
T5	72.78[a]	18.20[a]	45.10[ab]
T6	76.10[a]	16.00[a]	46.80[a]
T7	75.10[a]	15.60[a]	42.50[ab]
T8	69.40[a]	15.80[a]	44.20[ab]

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

yield compared to its foliar fertilizer counterparts (basal, PI and at Heading) that is, T4, T6 and T8. On the other hand, the fertilizer application as basal and at PI, T5 (150ml Boost Xtra/15l H_2O) had a higher grain yield than the T1 soil-applied fertilizer (NPK). Amongst the foliar fertilizer treatments also, T5 and T6 (150ml Boost Xtra/15l H_2O) grain yield was higher than its foliar fertilizer counterparts T3, T4, T7 and T8. The total cost of fertilizer and application for each treatment is presented in Figure 2. The cost of applying the foliar fertilizer (Boost Xtra) is less than the cost of applying the soil-applied fertilizer (NPK).

DISCUSSION

From the results obtained, growth parameters such as plant height and number of tillers were not significantly different under the different mode of fertilizer applied that is, soil-applied and foliar fertilizer application, though similar researches have reported increase in plant height and number of tillers using foliar fertilizers (Chaturvedi, 2005; Ahmad et al., 2007; Chandramohanan et al., 2014). That notwithstanding, numerically, the foliar fertilizer (Boost Xtra) treatments had slightly more tillers than the soil-applied treatments. In terms of volume of foliar fertilizer applied also, application of 150ml Boost Xtra/15l H_2O (T5 & T6) seems to be better than application at 100ml Boost Xtra/15l H_2O and 200ml Boost/15l H_2O).

Straw weight was significantly increased by the foliar fertilizer application. This could be attributed to the micronutrient in the foliar fertilizer (Boost Xtra). This is in agreement with research done on a similar cereal crop, wheat by Yassen et al. (2010) who reported that, foliar spray increased amongst other parameters straw weight of wheat. Increase in straw weight of a wheat crop by the application of foliar fertilizer, has also been reported by Matilo et al. (2006).

Chlorophyll content measured, showed that the foliar fertilizer (Boost Xtra) treatments were greener than the soil-applied treatments. From this observation, it can be concluded that application of fertilizer by the foliar method, did not negatively affect the health (nutrient wise) of the crops.

For the number of panicles per plant, statistically, no significant difference was observed between the foliar fertilizer (Boost Xtra) treatments and the soil-applied (NPK) treatments, but numerically the foliar fertilizer treatments were slightly higher than the soil-applied treatments. However, similar research on wheat by Soylu et al. (2005) reported an increase in number of panicle /m^2 with foliar treatment of several micronutrients alone or in combination.

Number of grains per panicle also statistically recorded no significant differences between the treatments. A general conclusion on the performance of the treatments in terms of the number of panicles and number of grains would be that, in the absence of soil-applied fertilizer (NPK), foliar fertilizer like Boost Xtra can be used in the

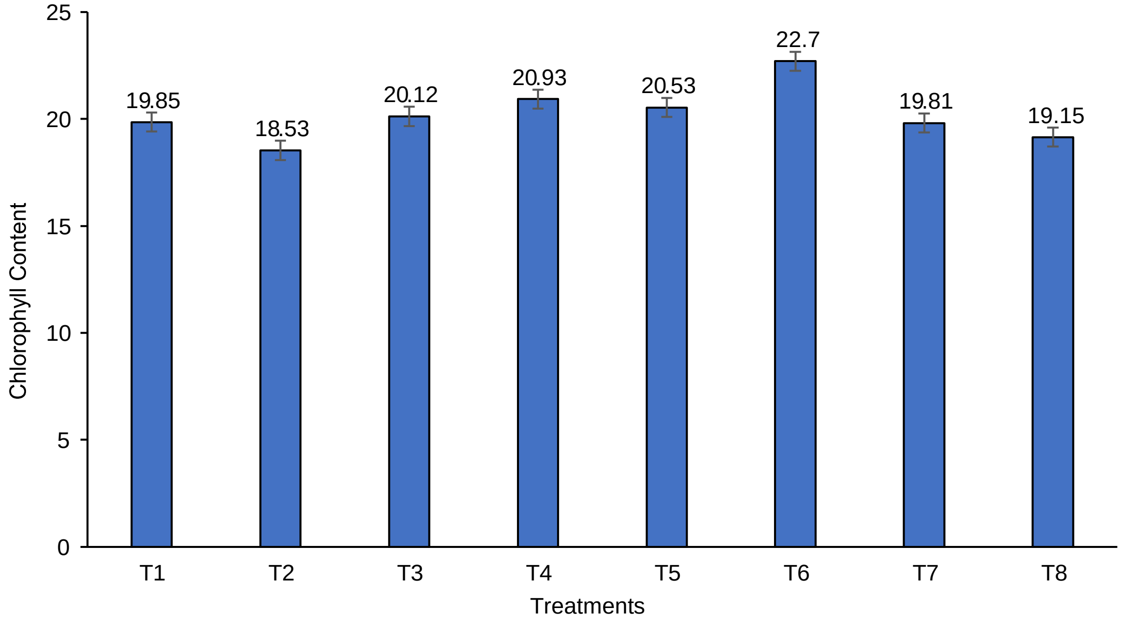

Figure 1. Chlorophyll content.
Source: Authors

Table 6. Effect of treatment on 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/m^2)
T1	13.4^a	100.9^a	79.3^{ab}	25.0^a	857.0^b
T2	15.0^a	138.7^a	83.4^a	26.4^a	1449.0^a
T3	13.0^a	105.2^a	54.8^b	29.2^a	539.0^b
T4	17.6^a	96.2^a	54.9^b	25.4^a	750.0^b
T5	17.0^a	111.3^a	65.2^{ab}	25.6^a	950.0^{ab}
T6	18.0^a	100.3^a	64.1^{ab}	27.2^a	815.0^b
T7	14.2^a	118.3^a	72.9^{ab}	26.8^a	647.0^b
T8	16.8^a	91.9^a	63.6^{ab}	27.0^a	733.0^b

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

cultivation of rice to give a good output.

Significant differences were observed for the percentage ripened grains. The soil-applied fertilizer treatments had more ripened grains than the foliar fertilizer treatments. Amongst the foliar fertilizer treatments, the trend of increase was in accordance to the volume of the foliar fertilizer applied. The 200 ml Boost Xtra/15l H_2O (T7) followed by T5 (150 ml Boost Xtra/15l H_2O) and the lowest T3 (100 ml Boost Xtra/15l H_2O) for the 2 stages of growth application; and for the 3 stages also T8 and T6 were the same and the lowest was T4. Basically, the 2 or 3 stages of fertilizer application did not influence the % ripened grain significantly. Meaning for good grain filling the availability of assimilates among other factors is the main factor not necessarily period of fertilizer application. The 1000 grain weight recorded no significant differences.

Significant difference was also observed for the grain yield. The soil-applied fertilizer treatment at basal, PI and at heading (T2) gave a significant output compared to the other treatments. Generally, the grain yield results shows that fertilizer application at basal, PI and heading was slightly beneficial than the two 2 stages (basal and at PI).

Amongst the Foliar fertilizer treatments, T5 and T6 (150 ml Boost Xtra/15l H_2O) yielded better than the 100ml Boost Xtra/15l H_2O (T3 and T4) and 200ml Boost Xtra/15l H_2O (T7 and T8) giving an indication that, application of Foliar fertilizer, Boost Xtra at 150ml/15l H_2O was better than foliar fertilizer at the 100ml Boost Xtra/15 H_2O (T3 and T4) and 200ml Boost Xtra/15l H_2O (T7 and T8).

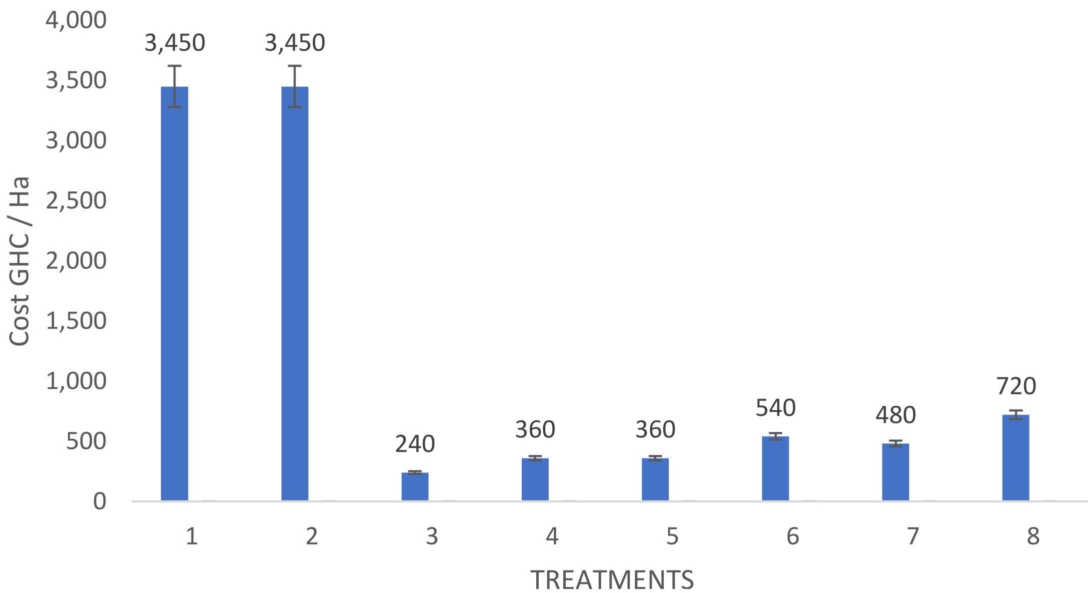

Figure 2. Total cost of fertilizer for each treatment.
Source: Authors.

On the whole, performance of the foliar fertilizer (Boost Xtra) treatments was encouraging and this could be attributed to the micronutrients in the foliar fertilizer (Boost Xtra) applied. Other researches done, have also reported a good output of the crop with application of foliar fertilizers. For instance, Hobbs and Gupta (2003) reported that foliar application of fertilizer elements increased grain yield of Aman rice and wheat. Ali et al. (2007) also reported a higher paddy yield with foliar fertilizer. Barut (2019) who researched on similar cereal crop wheat reported that foliar fertilizer treatments had positive effects on grain yield and quality of the wheat crop. Mesdah (2009) also reported a higher grain yield of wheat by the application of foliar fertilizer nutrients. Hamouda et al. (2015) also reported a similar finding.

It could be concluded based on the present findings that, foliar fertilizer like Boost Xtra application on rice crops could be another mode of supplying fertilizer nutrients to the crop in the absence of the soil- applied fertilizer (NPK) due to high cost and unavailability, and also, application at a rate of 150ml Boost Xtra/15 H_2O) either at the two stages or three of growth could be a better option than at 100ml Boost Xtra/15 H_2O and 200ml Boost Xtra/15l H_2O.

Conclusion

On the whole, the results suggest that the application of foliar fertilizer (Boost Xtra) at 150ml/15L H_2O either at the two stages (basal and PI) or three (basal, PI and heading) could be a better option than at 100ml/15L H_2O and 200ml/15L H_2O for the cultivation of rice.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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