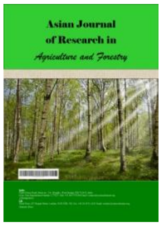

Asian Journal of Research in Agriculture and Forestry

4(4): 1-10, 2019; Article no.AJRAF.52194
ISSN: 2581-7418

Effect of Herbagreen Foliar Fertilizer on Growth and Productivity of Maize in the Mid-altitude Zone of Rwanda

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Authors' contributions

This work was carried out in collaboration among all authors. Authors LM and OT designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors IM and CK managed the analyses of the study. Author FM managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRAF/2019/v4i430070
Editor(s):
(1) Dr. Nebi Bilir, Professor, Faculty of Forestry, Isparta University of Applied Sciences, 32260 Isparta, Turkey.
Reviewers:
(1) Chemutai Roseline, Bukalasa Agricultural College, Uganda.
(2) Seweta Srivastava, Lovely Professional University, India.
(3) Rahim Foroughbakhch Pournavab, Autonomous University of Nuevo Leon, Mexico.
Complete Peer review History: http://www.sdiarticle4.com/review-history/52194

Original Research Article

Received 28 August 2019
Accepted 01 November 2019
Published 04 December 2019

ABSTRACT

Maize (*Zea mays L)* is still largely a subsistence food crop under promotion as a food security crop and source of income for smallholders. It is grown in the mid altitude zone of Rwanda. Herbagreen is a Bio fertilizer, used successfully in agriculture in different countries of the world.

The objective of this study was to determine the maize response to herbagreen foliar fertilizer application and determine the optimum rate for maximum yield. This was done in Randomized

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Complete Bloc Design (RCBD) with four treatments, replicated in four times. Four treatments of herbagreen rates including T_1 as control, T_2=0.31Kg/ ha^{-1}, T3=0.63Kg/ha^{-1}and T_4=0.94Kg ha^{-1} of herbagreen foliar fertilizer. This was applied to a population of 53.333 plants/ha. The planting spacing was used at 75 cmX50 cm with 2 plants per hill. Analysis of variance for the different parameters measured showed that there was a high significant ($p<0.001$) among treatment for number of leaves, ear weight and grain yield. The effect of herbagreen foliar fertilizer differed significantly ($p<0.05$) for male flowering, female flowering, ear length, ear diameter and plant height. The maximum grain yield was 4.922 t ha^{-1} recorded with the application of 0.94 kg ha^{-1}, followed by 0.63 kg/ha which produced 4.629 t ha^{-1} also 0.31 kg ha^{-1}of herbagreen yielded 4.589 t ha^{-1} and lastly the minimum grain yield was found in control plots where it produced 3.569 t ha^{-1} The control plots did not receive any herbagreen foliar fertilizer. The optimum herbagreen foliar fertilizer rate for maximum grain yield was 0.94 kg ha^{-1} from the regression equation and the predicted grain yield at this rate was 4.8 t ha^{-1}. Herbargreen foliar application can increase Maize yield to a certain extent. However, further experiments need to be done to ensure the sustainability of the application.

Keywords: Herbergreen; fertilizer; maize; productivity; growth; Rwanda.

1. INTRODUCTION

During the recent decades, agriculture has had a lot of transformations. It contributed around 30% of the GDP and employed over 70% of the Rwandan population.

Maize (*Zea mays L)* is one of important food crops in Rwanda as it is currently grown in all Rwandan ecologies that include semi-arid, mid - altitudes (900-1450 m asl), moist mid- altitudes (1450-1700 m asl) and highlands >1700 m asl [1].

The optimum temperature for maize growth ranges between 15°C and 45°C [2], it does well on most soils but less on very heavy dense clay and very sandy soils, the soil should preferably be well-aerated and well-drained as the crop is susceptible to water logging (FAO, 2013). According to Arnon et al. & ISAR, [1], maize can grow well on a wide range of pH from 5.5 to 8.0; and its optimum pH is slightly acid to neutral between 6.0-7.0.

The crop covers about 241,817ha in the country (RAB, 2014) but production is concentrated mainly in the highland zone, as a staple food, it is consumed in several traditional food preparations (Nyirigira et al. 2005) [3]. Maize is an important source of many industrial products such as sugar, oil, flour, starch, syrup, brewer's grit and alcohol (Dutt, 2005), Corn oil is used for salad, soap-making and lubrication. Maize is a major component of livestock feed and it is palatable for poultry, cattle and pigs as it supplies them energy (Iken et al. 2001), its stalk, leaves, grain and immature ears are cherished by different species of livestock (Dutt et al., 2005) [3].

Despite investment aimed at boosting maize production in Rwanda, the objective of attaining potential production and self-sufficiency in maize has not been reached. The yield remains very low and the potential of 8 tons per hectare is still not achieved in the majority of maize producing areas.

The application of the agrochemicals have had some undesirable impacts such as loss or depletion of topsoil, a drop in the population of microorganisms and change in soil acidity [4]. The excessive use of such chemicals has resulted in pest resistance, resulting in the development of even stronger chemicals (Denholm and Williamson 2002) Kara and Sabir [5]. Consequently, the environment is damaged by toxic materials, chemical leaching into rivers and water reservoirs [5].

The methods of nutrient application play an important role in nutrient supply to plants since the efficacy of fertilizers applied to soil is low due to various losses and fixations [6]. Dewdar and Rady [7] stated that soil application of macronutrients is very expensive and the availability of macronutrients are affected by several environmental factors such as leaching, microbial immobilization, denitrification and volatilization. In contrary, foliar to feeding techniques as a particular way to supply nutrients minimize these factors and results in a rapid absorption [7,8]. Application of N, P and K in different ratios through foliar sprays is a modern method of fertilization in vegetable crops [6].

Foliar feeding is more effective and less costly in most cases [7,8].

Herbagreen is composed of Calcium oxide (CaO) 35,9%, magnesium oxide (MgO) 1,9%, Silicium dioxide (SiO2) 18,1%, Phosphorus (P2O5) 0,28%, potassium oxide (K2O) 0,1%, Sulfur (S) 0,52% and some others microelements in 1 µm granules. Herbagreen main component is calcite - a sediment limestone which is a natural product composed of the main components calcium, silicon, magnesium and iron [9].

The appropriate elucidation of physiological, biochemical, and molecular mechanism of nano particles in plant leads to better plant growth and healthier development, Nanotechnology as a new emerging and fascinating field of science, permits advanced research in many areas, and nanotechnology discoveries could open up new applications in the field of biotechnology and agriculture [10,11]. Therefore fertilizers are very important for plant growth and development, most of the applied fertilizers are rendered unavailable to plants due to many factors and natural processes such as leaching, degradation by photolysis, hydrolysis, and decomposition. Hence, it is necessary to minimize nutrient losses in fertilization, and to increase the crop yield through the exploitation of new applications with the help of nanotechnology. One of the relevant discovers in agriculture is Herbagreen fertilizer, produced through Tribo-mechanic process [9].

2. MATERIALS AND METHODS

2.1 Site Description

The experiment was conducted in the fields of Tonga experimental station located in Ngoma sector of Huye District in the Southern Province of Rwanda. Tonga experimental station is also situated in the mid altitude zone, at an altitude of 1600 m above sea level but can attend over 1700 m in Southern part of the region., longitude 29°- 43' 43,1''E, latitude 2°-35' 2,8''S and at a slope of 23%, surrounded by two hills (Mbonigaba, 2007). This site is characterized by humid tropical climate with an annual rainfall between 900 to 1400 mm and the annual average temperature between 19°C and 21°C. It is characterized by 2 to 3 months of dry season (June and September) in which the precipitation can go below 50 mm (Mbonigaba and Culot, 2004). The station has a tropical climate of AW_3 type according to Köppen classification, the soil was relaxed, compression free and crumbly (Ilaco, 1985).

2.2 Materials

The experimental materials that was used during the study are Katumani maize variety from Agrosud Huye, NPK (17-17-17), herbagreen foliar fertilizer and Urea.

2.3 Methods

2.3.1 Land preparation

The experimental field was ploughed manually using a hand hoe before planting. All plant residues and weeds were buried to allow time to form humus. The seedbed was hallowed and leveled using hoe during the second ploughing followed by division of the field into sixteen plots. After site preparation and before planting; soil samples was taken and analyzed.

2.3.2 Tillage

Tillage consisted in opening the ripen crust of soil to create favorable conditions for seed placement and plant growth. The primary tillage was done in December 2018 by removing plant residues, breaking bigger soil particles and taking needed dimension and making the soil suitable for seed germination.

2.3.3 Sowing

Seeds have been sown in the rows at the spacing of 50 cm after seed placement and 75 cm between rows (75 cmx50 cm); the seeds were put into the holes made within the lines at the rates of two seeds per hole per hill.

2.3.4 Maintenance of the experiment

2.3.4.1 Thinning and gapping

Three weeks after planting, we replaced the dead seedlings and we removed the excessive ones for avoiding the competition between crops.

2.3.4.2 Weeding

For avoiding weed appearance and loosening the soil, we did two weeding: the first was done weeks after planting this coincided with urea application and the second weeding 14 days after first weeding this also coincided with urea.

2.3.5 Experimental design, treatments and laboratory/Analytical methods

The experiment was laid out in Randomized Complete Block Design (RCBD) with four replications and four treatments. The treatments included T_1 as control T_2 with 0.31 $kgha^{-1}$ of herbagreen, T_3 with 0.63 Kg/ha of herbagreen and T_4 with 0.94 $kgha^{-1}$ of herbagreen foliar fertilizer, combined with NPK (17-17-17) at 300 $kgha^{-1}$, one spoon table per hill, organic and inorganic fertilizers was applied uniformly to all plots including the control, the plant space was 75 cm x 50 cm at 2 plants per hill and hence planting density of 53,000 plants/ha was obtained. Soil total nitrogen, ammonium and nitrate, microbial C, N, P and plant total nitrogen were analyzed in the Laboratory of the Soil Testing Laboratory of RP, IPRC Kigali.

2.3.6 Data collection

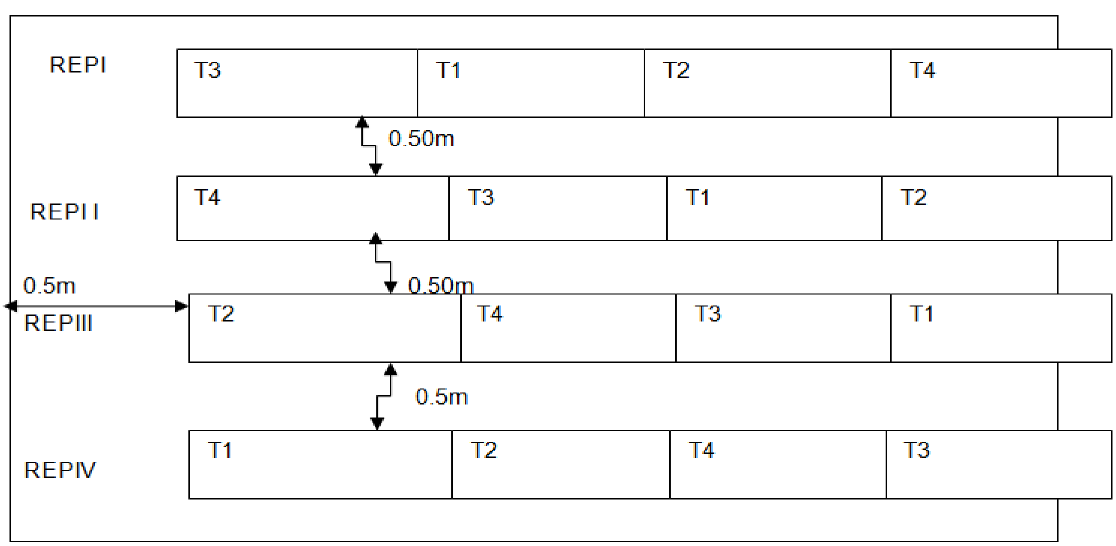
Data collection started immediately after maize seedlings emergence .The plant height was determined by measuring the average heights of five representative plants from the base of the plant to the base of the tassel in each plot. Maize streak virus, Turcicum Leaf Blight and rust disease symptoms were scored on a 1 to 5 scale. 1 denoting apparently healthy plants and 5 denoting all plants bore symptoms (Verchot et al., 2010). Stem borer infestation was scored on a similar 1 to 5 scale, where 1= healthy plants and 5= Infected plants. The plant height has been evaluated in three times after plantation recorded in centimeter (cm), number, plant aspect, husk cover aspect, leaves number per plant, ear length and ear diameter recorded in cm, root lodging and stalk lodging recorded before harvesting, number of days to mid-anthesis and mid-silking were recorded as the dates when 50% of the plant population were shedding pollen and showing silks respectively. Anthesis-Silking Interval (ASI) was calculated as a difference between days to 50% silking and 50% pollen shed, ear length and ear diameter recorded in cm. The weight of grain per plot was recorded after shelling and the Grain moisture content in (%) at harvest was taken by obtaining grain samples from each plot whereby each grain sample was thoroughly mixed and placed in moisture proof container to avoid moisture loss. The Weight of Thousand Grains (WTG) was measured in gram for each plot by using electronic balance. Then the moisture content from each sample was measured using a grain moisture meter. Ear weight (kg) was accessed as the weight of cobs per plot and grain yield expressed in terms of kg per ha considering shelling percentage of 80% at 15% moisture content. The following formula was used to calculate the grain yield:

$$GY = [(FW/PLS)*10000*(100-\%GM)/85*0.8]$$

Where:

GY = Grain Yield (Kg/ha).
FW = Field Weight (Kg) at harvest per plot
PLS = Plot Size (m^2).
GM = Grain Moisture (%) at harvest.

Table 1. Field layout for maize trial at Tonga experimental site in 2018/2019 season B



2.3.7 Data analysis

Data have been organized by using excel program (2010) while the analysis of variance has been done by using GENSTAT 4th Edition and it helped us to detect variations between treatments. The mean comparison has been done by using the LSD (Least Significant Difference) method at the 5% level of probability to identify differences among the treatments for the parameters measured.

3. RESULTS AND DISCUSSION

3.1 Results

The data revealed in Table 5 indicated that there is a positive effect of herbagreen foliar fertilizer vis a vis on the rate of 0.31 Kg/ha whereas maize height increased 196.9 cm even though other rates of HBG were not performed. The study also illustrated that the rate of 0.94 Kg/Ha has positive impact on ear length of maize where it is found to have 22.95 cm in its plot. It is also found in the plot applied 0.63 and 0.94 Kg/ha has positive impact on ear diameter (20.55 cm) respectively. 0.63 Kg/ha has high number of ear than other rates of HBG where it has almost 2 ears per plant (1.925 cm) also the number of leaves increased compared to other rates of HBG.

The data revealed in Table 6 that the application of HBG in field resulted 20.81% of moisture content, here 0.63 HBG has better moisture content where it has 18%. The data indicates that on the use of HBG foliar fertilizer has positive effect on field weight where it weighs 2.378 Kg but 0.63 Kg/Ha generally weigh highly than other rates of Herbagreen (3.375 Kg). By the use of Electronic balance 1000 grain of maize weigh 0.343 Kg but for the rate of 0.63 Kg/Ha of HBG weighs higher than other 0.475 Kg.

The study indicated that there is a good appearance of husk cover of maize and scored in number one (1) class. By the use of HBG foliar fertilizer there is no root lodging of maize in the field and scored good (1) and stem lodging except in the field applied by 0.31 Kg/Ha of Herbagreen foliar fertilizer. The maize plant has the best aspect and bad ear of maize except on the rate of 0.31 Kg/Ha of HBG. On the use of HBG there is no Maize Streak Borer in the field of maize (Table 7).

The analysis of variance showed that herbagreen foliar fertilizer effects were highly significant ($p<0.001$) for number of leaves per plant, and grain yield (Tables 2 and 3) and the results from the analysis of variance also showed that variety effects influenced significantly ($p<0.05$) ear length, ear diameter, ear per plant, plant height, silking, ear length and 1000 grains weight (Tables 2and 3).

The differences among herbagreen foliar fertilizer rates were highly ($p<0.001$) significant, number of leaves per plant, ear length and grain yield (Tables 3 and 4). The highest plant height was recorded with application of 0.31 $kgha^{-1}$ of HG, followed by 0.63 $kgha^{-1}$, 0.94/ha of HG and the lowest plant height was recorded over the control where no HG foliar fertilizer was applied (Table 5). The herbagreen rate accelerates in early flowering of maize was 0.94 $kgha^{-1}$, followed by 0.31 $kgha^{-1}$ followed by 0.63 $kgha^{-1}$ and last one found in control plots (Table 5). In general, the plants shaded pollen before the ears (female flowers) appeared; there was an interval of 3 days between male flowering and female flowering. The earliest plots whose the plants shedding pollen at 71days after planting, the latest were at 77th day after planting (Table 5). Similarly, the first treatments to silk were at 74 days after planting and the latest was at 79.75 days found in control plots days after planting. The highest number of ears per plant was obtained where 0.63 $kgha^{-1}$was applied followed by 0.94 $kgha^{-1}$ and the least number of ears per plant was observed with the control. The effect of herbagreen on ear diameter showed that there was the same rate of application where their maximum fertilizer was 0.61 and 0.94 $kgha^{-1}$. The effect of herbagreen foliar fertilizer showed that the maximum rate for high weight in 1000 grain was 0.94 $kgha^{-1}$ in obtaining 0.388 $kgha^{-1}$ and the last was control. The maximum of HG which makes the field to weigh high was also 0.94 $kgha^{-1}$ for the weight of 3,125 $kgha^{-1}$ compared to other rates (Table 6). Application of 0.94 $kgha^{-1}$ of HG also gave the maximum grain yield of 4.922 t ha^{-1}(Table 6) and the least grain yield was recorded with the control which gave 3.569t ha^{-1} (Table 6). Herbagreen foliar fertilizer showed that there was no significant difference for stem lodging, root lodging, Anthesis Silking Interval (ASI), husk cover aspect, plant aspect, ear aspect and maize diseases among this herbagreen foliar fertilizer rates (Tables 2 and 7).

The regression equation of the resulting response curve was stated as Grain yield=-1.861(HG) ^{2}+3.052(HG) +3.633. From the regression equation the optimum Herbagreen foliar fertilizer rate for maximum grain yield was 0.94 kg ha^{-1} (Fig. 1) and the predicted grain yield at this fertilizer rate was 4.8 t ha^{-1}.

3.2 Discussion

This study showed the significant increase of grain yield of herbagreen foliar fertilizer application up to 37.9%for maximum herbagreen, the following was increased up to 29%, and last was 28% compared to grain yield of control plots.

The data revealed in Table 5 indicated that there is a positive effect of herbagreen foliar fertilizer vis a vis on the rate of 0.31 Kg/ha whereas maize height increased 196.9 cm even though other rates of HBG were not performed.

The study also illustrated that the rate of 0.94 Kg/Ha has positive impact on ear length of maize where it is found to have 22.95 cm in its plot. It is also found in the plot applied 0.63 and 0.94 Kg/ha has positive impact on ear diameter (20.55 cm) respectively. 0.63 Kg/ha has high number of ear than other rates of HBG where it has almost 2 ears per plant (1.925 cm) also the number of leaves increased compared to other rates of HBG.

Table 2. Mean squares and their significance levels from the analyses of variance for six agronomic growth parameters in maize evaluated at four herbagreen foliar fertilizer rates in the mid-altitude zone of Rwanda in the 2018/2019 season B

Source of variation	Df	Plant height (cm)	Leaves per plant (number)	Mid-anthesis (days)	Mid-silking (days)	ASI(days)	Ear length(cm)
Replication	3	275.3	0.8958	8.167	1.5625	1.5625	1.520
Herbagreen	3	1633.4*	3.1492**	8.833	0.0625*	0.0625	2.826*
Error	9	357.2	8.833	30.000	2.826	0.8958	18.519
Total	15						
Mean		137.7	11.19	73.00	5.94	20.76	20.76
CV		10.3	3.8	4.1	3.4	32.2	8.2

**, **: Significant at the 5 and 1% levels of probability respectively*

Table 3. Mean squares and their significance levels from the analyses of variance for six agronomic yield parameters in maize evaluated at four herbagreen foliar fertilizer rates in the mid- altitude zone of Rwanda in the 2018/2019 season B

Source of variation	Df	1000 grains weight (Kg)	Ear diameter	Ear per plant	Grain moisture	Field weight (kg)	Yield
Replication	3	0.002122	2.7290	0.07396	27.69	0.08547	1036521
Herbagreen	3	0.013817*	1206*	0.41063*	45.69	1.17547**	4131731**
Error	9	0.009317	40.5178	0.07507	103.06	0.19391	877509
Total	15						
Mean		0.343	19.99	1.594	20.81	2.378	4418
CV		20.5	3.6	17.2	16.3	6.2	7.1

**, **: Significant at the 5 and 1% levels of probability respectively*

Table 4. Mean squares and their significance levels from the analyses of Variance for seven agronomic aspects parameters in maize evaluated at four herbagreen foliar fertilizer rates in the mid-altitude zone of Rwanda in the 2018/2019 season B

Source of variation	Df	Root lodging	Stem lodging	MSB(Score)	Rust diseases (Score)	Plant aspect	Ear aspect	Husk cover aspect (Score)
Replication	3	0.0625	0.065	0.0625	0.0625	0.25	0.25	0.0625
Herbagreen	3	0.0625	0.065	0.0625	0.0625	0.25	0.5278	0.06250
Error	9	0.06250	0.065	0.0625	0.0625	0.2500	0.7500	0.06250
Total	15							
Mean	1.062		1.062	1.062	1.062	1.12	1.38	1.062
CV	23.5		23.5	23.5	23.5	44.4	52.8	23.5

Table 5. Mean response to eight agronomic growth parameters due to four herbagreen foliar fertilizer rate in the mid-altitude of Rwanda in season of 2018/2019B

HG (kg/ha)	Plant height(cm) after 90 days	Mid-anthesis (days)	Mid-silking (days)	ASI (days)	Ear length(cm)	Ear diameter (cm)	Ear per plant	Leaves number per plant
0	153.8	77.00	79.75	2.75	17.80	18.48	1.250	9.90
0.31	196.9	71.50	74.50	3.00	21.27	20.40	1.400	11.75
0.63	195.6	72.50	75.50	3.00	21.04	20.55	1.925	11.80
0.94	187.5	71.00	74.00	3.00	22.95	20.55	1.800	11.30
Mean	137.7	73.00	75.94	2.94	20.76	19.99	1.594	11.19
$LSD^{0.05}$	30.23	4.754	4.132	1.514	2.689	1.151	0.4383	0.687
CV%	10.3	4.1	3.4	32.2	8.1	3.6	17.2	3.8

Table 6. Mean response to four agronomic yield parameters due to four herbagreen foliar fertilizer rate in the mid-altitude of Rwanda in season of 2018/2019B

HG (kg/ha)	Grain moisture	Field weight (kg)	1000 grain weight(Kg)	Grain yield/Tone
0	22.25	1.950	0.258	3.569
0.31	21	2.500	0.350	4.589
0.63	18	3.375	0.475	4.629
0.94	22	2.688	0.388	4.922
Mean	20.81	2.378	0.343	4.418.
LSD	5.413	0.2348	0.0737	499.5
CV%	16.3	0.2348	20.5	7.1

Table 7. Mean response to seven agronomic aspects parameters due to four herbagreen foliar fertilizer rates in season 2018/2019B

HG (kg/ha)	Husk cover	Root lodging	Stem lodging	Plant aspect	Ear Aspect	RST (score)	MSB (score)
0	1.250	1.25	1.000	1.50	2.00	1.250	1.250
0.31	1.000	1.000	1.250	1.00	1.25	1.000	1.000
0.63	1.000	1.000	1.000	1.00	1.00	1.000	1.000
0.94	1.000	1.000	1.000	1.00	1.25	1.000	1.000
Mean	1.062	1.062	1.062	1.12	1.38	1.062	1.062
LSD	0.399	0.3999	0.3999	0.800	1.162	0.3999	0.3999
CV%	23.5	23.5	23.5	44.4	52.8	23.5	23.5

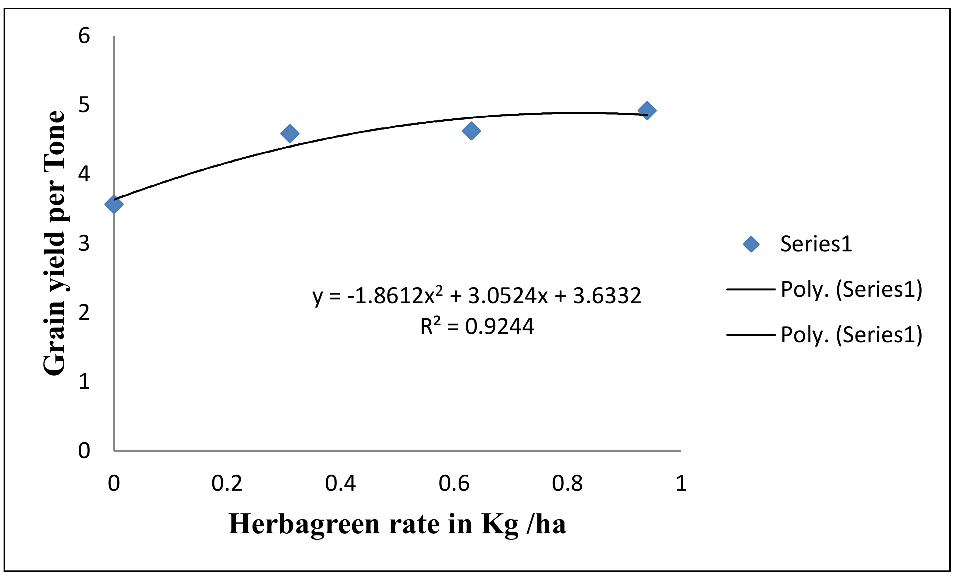


Fig. 1. Maize grain yield response to herbagreen foliar fertilizer application in Tonga station

The data revealed in Table 6 that the application of HBG in field resulted 20.81% of moisture content, here 0.63 HBG has better moisture content where it has 18%. The data indicates that on the use of HBG foliar fertilizer has positive effect on field weight where it weighs 2.378 Kg but 0.63 Kg/Ha generally weigh highly than other rates of Herbagreen (3.375 Kg). By the use of Electronic balance 1000 grain of maize weigh 0.343 Kg but for the rate of 0.63 Kg/Ha of HBG weighs higher than other 0.475 Kg.

The study indicated that there is a good appearance of husk cover of maize and scored in number one (1) class. By the use of HBG foliar fertilizer there is no root lodging of maize in the field and scored good (1) and stem lodging except in the field applied by 0.31 Kg/Ha of Herbagreen foliar fertilizer. The maize plant has the best aspect and bad ear of maize except on the rate of 0.31 Kg/Ha of HBG. On the use of HBG there is no Maize Streak Borer in the field of maize (Table 7).

Nonetheless, a number of studies have shown Positive effect of these fertilizers on the yield of various crops. Artyszak et al. [12] observed higher root, leaves, biological and technological yield of sugar beet (var. Danuśka KWS) with the application of marine calcite (herbagreen Basis). Chithrani et al. [13] and Raguposan et al. [14] received higher amount of fodder yield with the application of nano calcite for Sorghum.

Data results clearly revealed that herbagreen foliar fertilizer had a highly significant effect on plant height, number of ears per plant, ear length, ear diameter, ear per plant, plant height, silking, ear length and 1000 grains weight (Tables 2 and 3). This is performed by photosynthesis, breathing and may involve in growth and yield of maize.

Similar results were reported by Velkov and Petkova [15] that Herbagreen increases the number of fruits per plant in cucumber, melon and zucchini... Dimitrovski et al. [16] confirmed same results for rice. Herbagreen affects plants in different ways, by being directly involved in photosynthetic processes [15]. Carbon dioxide is included in the process of photosynthesis, this way CO2 from Herbagreen is absorbed directly in leaves thus increasing photosynthesis [17].

Herbagreen compared to NPK fertilizers is the considerably plant stimulants higher amount of silicon. Thus it is possible to continuously feed the plants through the plant leaves already from the seedling stage to the harvest maturity even on sites with high pH value and prevent biotic and abiotic stress situations Artyszak et al. [12] Thus grain yield have increased compared to control plots applied NPK(17-17-17) and diseases tolerance and water stress of maize… Hua et al. [18] have also reported that the application of nano calcium carbonate can increase plant protection against insect pests.

4. CONCLUSION

This study was conducted to determine the effect of herbagreen foliar fertilizer on growth and productivity of maize in the mid-altitude zone of Rwanda. The effect of four herbagreen rates of all treatments showed a significant higher growth and yield parameters of maize over the control where no herbagreen foliar fertilizer was applied. But the herbagreen foliar fertilizer which gave maximum yield in maize was 0.94 $kgha^{-1}$, followed by 0.63 $kgha^{-1}$ and 0.31 $kgha^{-1}$ in mid-altitude zone of Rwanda. Though the minimum of grain yield are found in control plots where there is no herbagreen foliar fertilizer applied.

The data results revealed that the optimum herbagreen foliar fertilizer rate for maximum grain yield was 0.94 $kgha^{-1}$.From the regression equation this fertilizer rate was expected to give 4.8t.

Herbagreen foliar fertilizer should be adopted by farmers because it gives high yield compared to mineral fertilizer as it have shown above to its increase to a certain extent. However, further experiments need to be done to ensure the sustainability of the application.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ACKNOWLEDGEMENTS

Grateful acknowledgements are made to College of Agriculture, Animal Science and Veterinary Medicine, University of Rwanda (CAVM / UR) and Protestant Institute of Arts and Social Science (PIASS) Management for the infrastructural support.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. ISAR. Maize Program Annual Report 2009. Institut des Sciences Agronomiques du Rwanda: Kigali, Rwanda; 2010.
2. FAO. Dynamic conservation of globally important agricultural heritage systems: For a sustainable agriculture and rural development. Parviz Koohafkan. FAO

Land and water division, Rome, Italy; 2012.
3. Narcisse M. Socio-economic factors affecting technical efficiency of small holder's maize production in Rwanda. Thesis, Kenyata University, Kenya; 2017.
4. Laary JK. Dry-season farming and agrochemical misuse in upper east region of Ghana: Implication and way forward. Journal of Agricultural, Food and Environmental Science. 2012;1(5):934-723.
5. Kara Z, Sabir A. Effects of herbagreen application on vegetative developments of some grapevine rootstocks during nursery propagation in glass house. In: 2nd International Symposium on Sustainable Development. 2010;127–132.
6. Chaurasia SNS, Singh KP, Mathura R. Effect of foliar application of water soluble fertilizers on growth, yield, and quality of tomato (*Lycopersicon esculentum* L.) Sri Lankan Journal of Agricultural Science. 2005;42:66-70.
7. Dewdar MDH, Rady MM. Influence of soil and foliar applications of potassium fertilization on growth, yield and fiber quality traits in two *Gossypium barbadense* L. varieties. African Journal of Agricultural Research. 2013;8(19):2211-2215.
8. Jamal Z, Hamayun M, Ahmed N, Chaudhary MF. Effect of soil and foliar application of different concentrations of NPK and foliar application of (NH4)2SO4 on different yield parameters in wheat. Asian Journal of Agronomy. 2006;5(2):251-256.
9. Prifti D, Maçi A. The effect of herbagreen fertilizer nanoparticles in wheat productivity through leaf pulverization. 2015;350–354.
10. Jones P. A nanotech revolution in agriculture and the food industry. Information Systems for Biotechnology; 2006.
Available:http://www.isb.vt.edu/articles/jun0605.htm
11. Mehta MD. From biotechnology to nanotechnology: What can we learn from earlier technologies? Bulletin of Science, Technology & Society. 2004;24:34-39.
12. Artyszak A, Gozdowski D, Kucińska K. The effect of foliar fertilization with marine calcite in sugar beet. Plant Soil Environment. 2014;60:413–417.
13. Chithrani K, Premalal GGC, Wickramasinghe HKJP. Effect of 'Calcite foliar fertilizer' on growth, yield and nutritional composition of sorghum (*Sorghum bicolor* L. Moench) cultivated under field condition as a fodder for dairy cattle. Proceedings of 14th Agricultural Research Symposium. 2015;302-306.
14. Raguposan U, Premaratne S, Premalal GGC, Samarasinghe SA. Effect of "Calcite foliar fertilizer" on growth, yield and nutritional composition of maize (*Zea mays* L.) and sorghum (*Sorghum bicolour* (L.) Moench) as fodder for dairy cattle. Proceedings of Faculty of Agriculture Undergraduate Research Symposium. 2014;91.
15. Velkov N, Petkova V. Influence of herbagreen mineral fertilizer on seed production of cucumber, melon and zucchini. In: Agricultural Science and Technology. 2014;6(1):63-67.
16. Dimitrovski T, Andreevska D, Andov D, Simeonovska E. Effect of ecological fertilizers herbagreen and megagreen on some morphological and productive properties of rice (*Oryza sativa* L.) 5th Congress of Ecologists of Republic of Macedonia with International Participation, Ohrid, Macedonia; 2016.
17. Dumancic D. Herbagreen (Practical information); 2010.
Available:http://5k.web.tr/dokuman/Prof_Dr_Dumancic_Herbagreen_Article.doc.
(Date of Accession 2019-08-25)
18. Hua KH, Wang HC, Chung RS, Hsu JC. Calcium carbonate nano particles can enhance plant nutrition and insect pest tolerance. Journal of Pesticide Science. 2015;40(4):208-213.

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