EFFECT OF HERBAGREEN FOLIAR FERTILIZER ON GROWTH AND PRODUCTIVITY OF MAIZE IN THE MID-ALTITUDE ZONE OF RWANDA

ABSTRACT (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)

Maize(*Zea mays L)* is still largely a subsistence food crop under promotion as a food security crop and source of income for smallholders that can be grown in the mid altitude zone of Rwanda.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 complete bloc design (RCBD) with four treatments, replicated in four times. Four treatments of herbagreen rates including T_1 as control =0kg ha^{-1}, T_2=0.31Kg/ha, T3=0.63Kg/ha^{-1}and T_4=0.94Kg ha^{-1} of herbagreen foliar fertilizer was applied and a population of 53.333plants/ha was used, planting at 75cmX50cm spacing 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 4.922t ha^{-1} recorded with the application of 0.94 kg ha^{-1}, followed by 0.63 kg/ha which produced 4.629t ha^{-1} also 0.31kg ha^{-1}of herbagreen yielded 4.589t ha^{-1} and lastly the minimum grain was found in control plots where it produced 3.569 t ha^{-1} where they didn't recognize any rate of 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}.

Keywords: Herbergreen, Fertilizer, Maize,Productivity.

1. INTRODUCTION (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)

Maize (*Zea mays L)* is one of important food crops in Rwanda (Ngaboyisenga *et al.*, 2001,2017),it is currently grown in all Rwandan ecologies that include semi-arid, mid - altitudes (900-1450m asl), moist mid- altitudes (1450-1700 m asl) and highlands >1700 m asl (ISAR, 2009).

The optimum temperature for maize growth ranges between 15^0 C and 45^0 C (FAO.org, 2012), 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.org, 2013). According to

Arnon *et al.,(*1975,2013), 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 between6.0-7.0.

The crop covers about 114,800 ha in the country (FAO.org, 2009) 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),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 to poultry, cattle and pigs as it supplies them energy (Ikene*t al.,* 2001),its stalk, leaves, grain and immature ears are cherished by different species of livestock (Dutt *al.,* 2005,2013).

Maize is a primary source of energy supplement and can contribute up to 30 percent protein, 60 percent energy and 90 percent starch in an animal's diet (Dado *al.,*1999,2016).

This study focused on investigating on herbagreen foliar fertilizer on maize growth and yield in mid altitude zone of Rwanda.

2. MATERIAL AND METHODS

2.1.Site description

The experiment will be 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 1700m 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 1400mm and the annual average temperature between 19^{0}C and 21^{0}C. It is characterized by 2 to 3 months of dry season (June and September) in which the precipitation can go below 50mm (Mbonigaba and Culot, 2004). The station has a tropical climate of AW_3 type according to Köppen classification (Ilaco, 1985)

2.2.Materials

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

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 50cm after seed placement and 75cm between rows (75cmx50cm); 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.

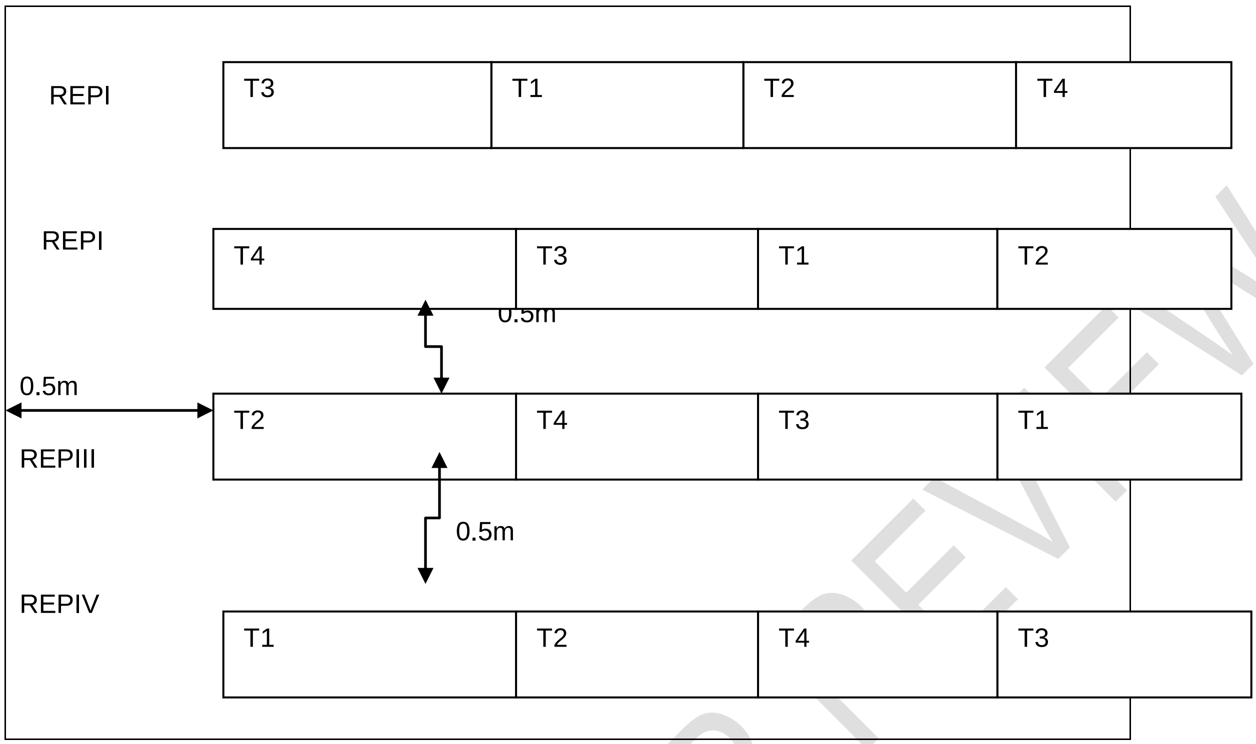
2.3.4.2.Weeding

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 and treatments

The experiment was laid out in randomized complete block design having four replication and four treatments. The treatments included T_1 as controlT_2 with 0.31kgha^{-1} of herbagreen,T_3 with 0.63Kg/ha of herbagreen andT_4 with0.94kgha^{-1} of herbagreen foliar fertilizer, combined with NPK (17-17-17) at 300kgha^{-1}, one spoon table per hill, organic and inorganic fertilizers will be applied uniformly to all plots including the control, the plant space will be 75cmx 50 cm at 2 plants per hill and hence planting density of 53,000 plants/ha will be obtained**.**

Table 1: Field Layout for maize trial at Tonga experimental site in 2018/2019 season A



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, rootlodging 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.**

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

1.RESULTS

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 (Tables2 and3) 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 0.31kgha^{-1} of HG, followed by 0.63kgha^{-1},0.94/ha of HG and the lowest plant height was recorded over the control where no HG foliar fertilizer was applied (Table5).The herbagreen rate accelerates in early flowering of maize was 0.94kgha^{-1}, followed by 0.31kgha^{-1} followed by 0.63kgha^{-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 (Table5). 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 0.63kgha^{-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 1000grain was0.94 kgha^{-1} in obtaining 0.388kgha^{-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 (Table6).Application of 0.94 kgha^{-1} of HG also gave the maximum grain yield of 4.922t ha^{-1}(Table6) 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 (Table2 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 0.94kg ha^{-1} (Fig.1) and the predicted grain yield at this fertilizer rate was 4.8t ha^{-1}

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

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

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 2018/2019season

Source of Variation	Df	Root lodging	Stem lodgin	MSB(Score)	Rust disease	Plant aspect	Ear aspect	Husk cover

			g		s (Score)			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 of2018/2019

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 2018/2019.

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 six agronomic aspects parameters due to four herbagreen foliar fertilizer rates in the mid altitude of Rwanda in season of2018/2019

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

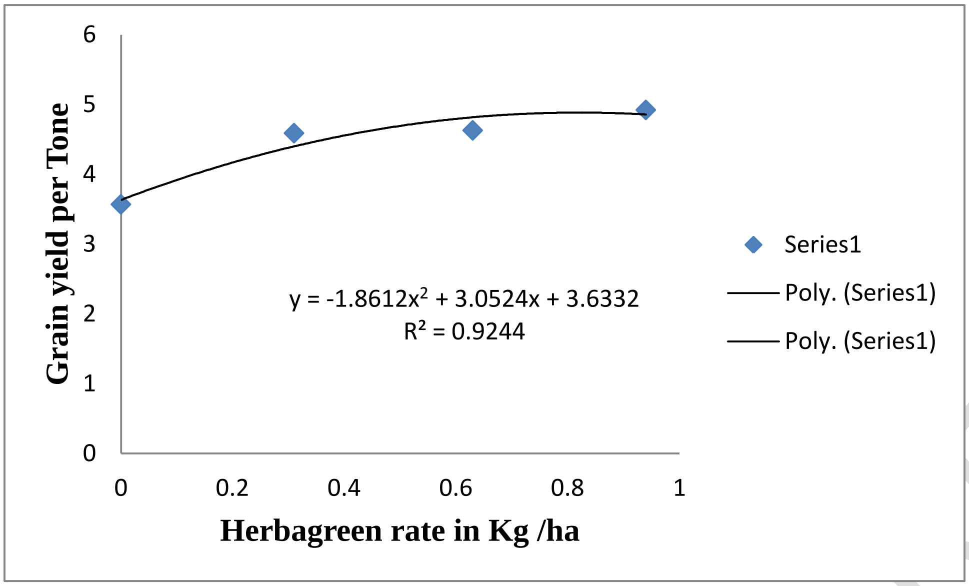


Figure 1: Maize grain yield response to herbagreen foliar fertilizer application in Tonga station

2.DISCUSSION

This study showed the significant increasement 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. These findings are approach to Sanovita (2011) for stating that maize grain yield increases up to23%.

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 2and 3).This is performed by photosynthesis and breathing (Drissi et al., 2009) and may involve in growth and yield of maize.

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 (Sanovita, 2011).Thus grain yield have increased compared to control plots applied NPK(17-17-17) and diseases tolerance and water stress of maize. This confirms also by ICYEZA N. (2008) who obtained the average yield of 4.4 t/ha for maize in mid altitude zone of Rwanda by using NPK 17:17:17 at the rate of 50 kg N ha^{-1}, 50 kg K_2O ha^{-1}, and 50 kg P_2O_5 ha^{-1} and supplemented with 50 kg N ha^{-1} as urea.

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 0.94kgha^{-1}, followed by 0.63kgha^{-1}and0.31kgha^{-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 0.94kgha^{-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 increasement.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. 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.

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